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SURGERY OF THE NECK, THORAX AND SPINAL COLUMN.

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CONTENTS.

MALFORMATIONS, INJURIES, AND DISEASES OF THE NECK.

CHAPTER I. PAGE
Malformations of the Neck 17

CHAPTER II.
Injuries of the Neck 40

CHAPTER III.
Diseases of the Neck 66

MALFORMATIONS, INJURIES, AND DISEASES OF THE LARYNX AND TRACHEA.

CHAPTER IV.
Malformations of the Larynx and Trachea—Laryngocele and Tracheocele 145

CHAPTER V.
Injuries of the Larynx and Trachea 149

CHAPTER VI.
Diseases of the Larynx and Trachea 175

DISEASES AND INJURIES OF THE THYROID GLAND.

CHAPTER VII.
Diseases of the Thyroid Gland 297

CHAPTER VIII.
Injuries of the Thyroid Gland and of Goitres 344

CHAPTER IX.
Diseases of the Thymus 363

INJURIES, MALFORMATIONS, AND DISEASES OF THE THORAX AND ITS CONTENTS.

CHAPTER X.

PAGE
INJURIES OF THE THORAX 367

CHAPTER XI.

MALFORMATIONS OF THE THORAX 446

CHAPTER XII.

DISEASES OF THE CHEST-WALL 452

CHAPTER XIII.

DISEASES OF THE PLEURA 473

CHAPTER XIV.

SURGICAL DISEASES OF THE LUNGS 502

CHAPTER XV.

DISEASES OF THE MEDIASTINUM 530

CHAPTER XVI.

ANEURISMS OF THE THORACIC AORTA 541

CHAPTER XVII.

SURGICAL DISEASES OF THE PERICARDIUM AND HEART 548

CHAPTER XVIII.

SURGICAL DISEASES OF THE DIAPHRAGM 555

MALFORMATIONS, DISEASES, AND INJURIES OF THE MAMMARY GLAND.

CHAPTER XIX.

CONGENITAL MALFORMATIONS OF THE MAMMARY GLAND 562

CHAPTER XX.

INJURIES OF THE MAMMARY GLAND 563

CHAPTER XXI.

DISEASES OF THE MAMMARY GLAND 564

INJURIES AND DISEASES OF THE SPINAL CORD AND VERTEBRAL COLUMN.

INJURIES AND DISEASES OF THE SPINAL CORD AND ITS MEMBRANES.

CHAPTER XXII.

PAGE
Diseases and Injuries of the Membranes of the Cord 625

CHAPTER XXIII.

Injuries and Diseases of the Spinal Cord 628

MALFORMATIONS, INJURIES, AND DISEASES OF THE VERTEBRAL COLUMN.

CHAPTER XXIV.

Malformations of the Vertebral Column 652

CHAPTER XXV.

Injuries of the Vertebral Column 664

CHAPTER XXVI.

Diseases of the Spine 697

MALFORMATIONS, INJURIES, AND DISEASES OF THE NECK.

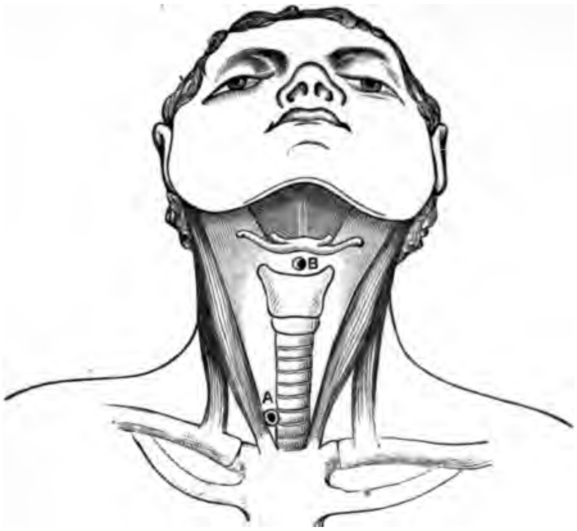
CHAPTER I.

MALFORMATIONS OF THE NECK.

FISTULA OF THE NECK.

Two cases of fistula of the neck were described by Hunczowski in 1789, and Dzondi reported 4 in 1829. Ascherson, however, first presented a correct explanation of this condition in 1832, and demonstrated the relation of fistulæ to developmental processes; he reported 11 cases. Heusinger collected 46 cases in 1864, Fischer 100 in 1880, and the statistics of Kostanecki and Milecki in 1890 contained 126 cases. Opinions as to the nature and genesis of fistulæ changed in the course of decades according to the status of embryological investigation, and a number of points which had hitherto been unexplained were rendered clear by a knowledge of the processes of development concerned and by microscopical examination of the material obtained through excision of fistulæ. The view that lateral fistulæ result from non-closure of the branchial clefts existing in early fœtal life has been shown to be incorrect; also Luschka's assumption that median fistulæ bear some relation to the trachea. In the present stage of our knowledge, lateral fistulæ must be considered as due exclusively to insufficient closure of the second branchial cleft, whereas median fistulæ owe their origin wholly to persistence of the ductus thyroglossus. The position of the external opening bears no relation to the origin of the fistula, for the mouth of the sinus may be in the median line, even in lateral fistulæ. The results of embryological investigation carried on by His, Kölliker, Born, Kostanecki, and Milecki correspond to these clinical facts: lateral complete fistulæ always open internally in the region of the second branchial cleft —*i. e.*, in the region of the tonsils; closure of the external fissure—*i. e.*, of the sinus cervicalis—may be incomplete anywhere in its course; the position of the external opening may vary, and therefore does not indicate the cleft from which the fistulous tract arose. In determining the origin of a fistula it is important to consider the relation of the track to the structures of the neck that develop in the branchial arches before the clefts are formed, namely, the nerves and arteries. Fistulæ arising from the second branchial cleft must lie below the facial and above the glossopharyngeal nerve, in their course to the pharyngeal wall, and above the beginning of the internal carotid. These relations have been worked out on the living and by anatomical preparations. The usual division into lateral and median fistulæ is justifiable only when lateral and median are considered with reference to the course of the canal, and not with reference to its opening, for, as previously stated, the external openings of lateral fistulæ in rare cases may be situated in the median line. It would be more correct to take the etiology into consideration, and divide fistulæ into those from the second branchial cleft and those of the ductus thyroglossus.

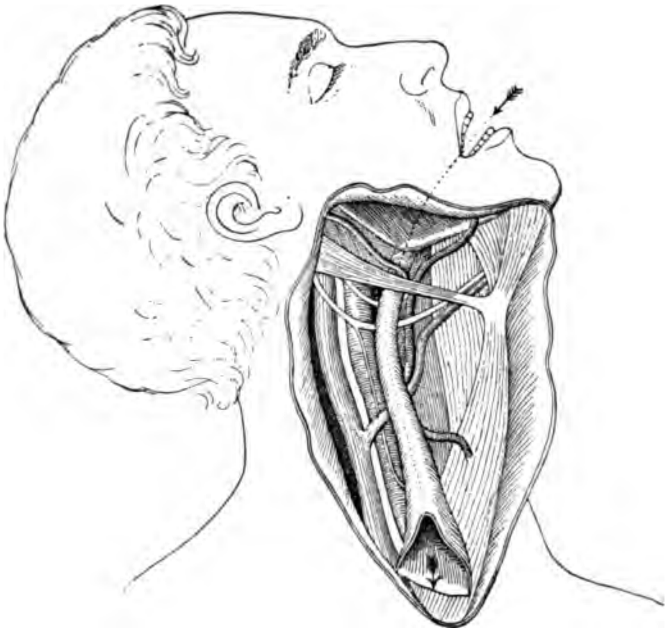
FIG. 1.



A, lateral sinus; B, median sinus.

Fistulæ from the Second Branchial Cleft.—The external opening lies in the anterior region of the neck between the internal margin of the sternomastoid and the middle line, and between the large cornu of the hyoid bone above and the jugulum below. It is most frequently observed immediately above the sternoclavicular joint, but sometimes is found higher up in the region of the cricoid, on a level with the upper margin of the thyroid or near the hyoid bone, and is usually very small, almost pin-hole, so that only the finest probe can be introduced. The internal opening is always in the region of the tonsil, the arcus palatopharyngeus, or in the lateral wall of the pharynx. Accurate information regarding the course of the fistulæ itself has been gathered partly from autopsies (Rosenbaum, Rehn, Watson), and partly from specimens obtained by operation (Karewski, Hildebrand). The coinciding results show that the fistulous canal perforates the subcutaneous tissue, platysma, and superficial fascia, running parallel to the sternomastoid on the deep fascia above the sternohyoid and sternothyroid muscle to the great cornu of the hyoid, then over the beginning of the internal carotid, between the internal and external carotid, and finally under the digastric into the lateral wall of the pharynx. It is very adherent to the sheath of the great vessels. Before entering the pharyngeal muscles it is crossed by the styloglossus and stylopharyngeus, the glossopharyngeal and hypoglossal nerve lying below. (Fig. 2.)

FIG. 2.



Incomplete lateral fistula. (Watson.)

Fistulæ are termed *complete* and *incomplete*, and the latter are called either *incomplete external* or *incomplete internal fistulæ* in accordance with the absence of the internal or external opening. The length of incomplete fistulæ varies. External fistulæ may be only 1 or 2 cm. deep or at times reach almost to the pharyngeal wall, while internal fistulæ may likewise be very short or extend nearly to the skin. The explanation of this varying relation is that the membrane originally subdividing the cleft does not always indicate the limit of the fistula, because incomplete fistulæ may develop from complete fistulæ by obliteration of the internal or external opening.

Complete fistulæ are not always formed as such, but may arise from incomplete ones by subsequent perforation externally or internally. Examination of the epithelium will give accurate information as to whether the origin of a fistula is from the internal or the external portion of the branchial cleft. The latter usually shows squamous epithelium, the former, cylindrical, and both kinds of epithelium meet at the place corresponding to the closing membrane. Incomplete external fistulæ therefore must always show squamous epithelium ; internal, incomplete

[illegible]

[illegible] Koenig [illegible] several dilatations [illegible] of the tract. The number of lumena [illegible] may be so great as to resemble a [illegible]. [illegible] of the tract is probably due to persistence [illegible] place.

Symptoms.—Congenital fistulæ are usually present at birth, but may [illegible] following rupture of a cystic swelling in the anterior [illegible] of the neck. The secondary fistulæ, complete or incomplete, [illegible] differ from congenital ones. In the majority of cases the [illegible] unilateral, bilateral fistulæ being uncommon; and the right side of the neck seems to be more frequently affected. The fistulous canal may often be felt beneath the skin as a hard strand, and a slimy fluid, sometimes clear, sometimes cloudy and pus-like, exudes from it. The amount of secretion varies, in some cases being so slight that only a drop appears at the opening every few days; while in others it [illegible] so considerable that the patient is much annoyed, especially by [illegible]. The lumen of the canal may vary considerably. Sometimes [illegible] so minute that the smallest probe can be introduced only with difficulty; [illegible] it may be so large as to permit the passage of fluid or [illegible]. Closure of the external opening may on account [illegible] to pain in the region affected and to difficulty in swallowing. In cases of incomplete internal fistulæ regurgitation [illegible] and symptoms similar to those of diverticulum of the [illegible], but in many cases the abnormality [illegible].

Prognosis.—The [illegible] is usually [illegible]. Only fistulæ of secondary origin may be confounded, for instance, with a sinus from suppurating glands. The extent and the direction of the fistula may be detected by passing a probe or by the injection of liquids having taste or color. It is rarely possible to pass a probe through the entire fistula into the pharynx (case of Heine and Lesser), as it is usually stopped at the level of the larynx or hyoid bone in a bend of the canal. The passage of a probe is an unreliable method of examination, the wall of the fistula being very delicate and easily perforated. The injection of liquids is usually decisive, as the taste may be appreciated with certainty by the patient or the fluid observed running into the pharynx.

Fistulæ of the Ductus Thyroglossus (Median Fistulæ proper).—Knowledge of these fistulæ is based on the results of investigations made by His, in 1891, relative to the ductus thyroglossus. In early fœtal life there is an epithelial connection between the cavity of the mouth and the middle lobe of the thyroid gland, the lobe being formed by an outgrowth of epithelium on the anterior œsophageal wall, near the tuberculum impar, where the latter meets the projections forming the root of the tongue. This outgrowth lengthens when the thyroid gland descends, forms a fine epithelial canal, the opening of which is on the upper surface of the base of the tongue, and remains permanently as the foramen cæcum. The connection between the tongue and the thyroid gland diminishes after the fifth week and usually disappears entirely; sometimes, however, the canal remains entirely as the ductus thyroglossus, or in sections as the ductus lingualis (foramen cæcum to the hyoid bone) or ductus thyroideus (middle lobe of the thyroid up to the hyoid bone). The ductus thyroglossus is formed before the cartilage of the body of the hyoid bone, and is intimately connected with it; when persistent, it may at times pass straight through the hyoid bone itself. The identity of median fistulæ of the neck and a persisting ductus thyroglossus has been placed beyond question by autopsies performed by Marshall as well as by the conditions found at operation. The fistula is originally an incomplete internal one reaching only to the vicinity of the skin, and becomes complete by secondary perforation of the latter, giving rise to a sinus leading from the tongue to the skin. The clinical observation that most cases of fistulæ are not congenital, but appear in later years, corresponds to the above statement. The external opening is situated in the middle line of the neck, at a varying level between the hyoid bone and the jugulum, and appears as a fine pin-head-sized opening or as an irregular moist surface. The canal can usually be traced to the hyoid bone as an indurated strand, but cannot be felt further; its course has been definitely ascertained by operation. This strand runs over the incisura thyroidea and the ligamentum hyothyroidea to the level of the hyoid bone exactly in the median line. It is in very close relation to or may even perforate the bone, and is then continued in the middle line to the root of the tongue (foramen cæcum). Subdivisions of the lumen mentioned in connection with lateral fistulæ are nearly always observed in median fistulæ. The lining epithelium is fimbriated cylindrical epithelium, which often becomes changed in the central portion of the tract (ductus lingualis) to endodermal squamous epithelium; and in the peripheral section—*i. e.*, from the end of the canal to the opening in the skin—ectodermal squamous epithelium is frequently found. The observations in Bergmann's clinic indicate the greater prevalence of median fistulæ, contrary to former statistics which seemed to show a marked predominance of the lateral variety.

Diagnosis.—The diagnosis is more difficult than in lateral fistulæ, the sinus being usually of secondary origin; and, as a rule, it is possible to pass a probe only as far as the hyoid bone, owing to the bend at that place. The characteristic epithelial covering of the canal will prevent error in doubtful cases.

Prognosis.—The prognosis of congenital fistulæ of the neck is favorable, and in many cases the condition does not cause annoyance. Complications may lead to trouble (retention inflammation), and the possibility of having a carcinoma develop from the epithelium later in life must not be forgotten.

Treatment.—Two methods are to be considered—the injection of caustic fluids and excision. Even if a cure has been obtained in individual cases by the injection method—*e. g.*, case of H. Rehn—the procedure is unreliable, for it will rarely accomplish sufficient destruction of the epithelial lining to obliterate the entire canal, with the many windings and constrictions in its course. Partial occlusion is associated with danger of retention of secretion and the formation of cysts. The injection of caustic fluids (tincture of iodine, zinc chloride solution, carbolic acid, silver nitrate solution, etc.) is not without risk on account of the communication with the pharynx in complete fistulæ. Total excision of the fistulous canal, as shown by experience, is the only safe method of procedure. It must be radical, as the smallest particle of sinus-wall retained will give rise to recurrence. The opening into the pharynx must be removed if possible, even if the tonsil has to be excised. (Karewski.) The anatomical position of the fistula, its intimate relation to the carotid sheath and to the hyoid bone, renders the operation extremely difficult, and it should be performed only by surgeons with complete control of technic and asepsis. As a very extensive skin incision is necessary for exposure, a long scar remains after the operation. Total excision of a median fistula is more difficult on account of its connection with the hyoid bone, and resection of the middle portion of this bone is necessary at times. (Schlange, König.) V. Hacker has made extirpation of complete lateral fistulæ easier by resecting the canal up to the digastric muscle, and then removing the central portion by means of a noose introduced from the mouth and pulling the sinus-wall through the wound below. This procedure is successful only when the connection of the fistulous canal to the surrounding tissue is very loose.

BRANCHIAL CLEFT OUTGROWTHS OF THE SKIN OF THE NECK.

Little outgrowths of skin are at times, although rarely, noted in the anterior region of the neck. They consist either of skin alone, or, which is more often the case, of skin and cartilage. The seat of these outgrowths corresponds to the seat of the fistulæ. They are found along the margin of the sternomastoid, at varying levels between the sterno-clavicular region and the hyoid bone, and are sometimes unilateral, sometimes bilateral. In the latter case they are often symmetrical. The size varies from that of a pea to that of the terminal phalanx of the little finger. These small tumors have the shape of a wart, a nipple, or a mushroom, and either hang down or stand out. Post-mortem preparations (Zahn), as well as excision on the living, have demonstrated that these outgrowths lie on the sternomastoid, and that the incorporated cartilage extends around the inner margin of the muscle for a short distance (0.5 to 1.5 cm.). They are not united with any of the deep-seated structures, as bone or cartilage, are only loosely connected with the fascia of the sternomastoid, and consist of skin, subcutaneous fatty tissue, and cartilage. The latter is cellular cartilage, and has been shown to have a surrounding perichondrium. (Zahn.)

Etiology.—There can be no doubt that these growths are derived exclusively from the second branchial arch. The third and fourth arches cannot be considered in surface formations owing to their depth. Indications of their branchiogenic nature are the seat of the outgrowths, their frequent occurrence around the orifices of branchial fistulæ, the combination with auricular tabs in the region of the ear, and the presence of cellular cartilage such as is found in the wall of fistulæ. (Karewski.)

Outgrowths in the anterior portion of the neck resembling ears, have been reported (polyotia). Cassebohm reports a child with two normal ears and two ears on the neck ; and Birkett the case of a well-developed girl in whom there was present on both sides, at about the middle of the sternomastoid, a large outgrowth resembling the lobe of an ear in shape and consistency and covered with fine hairs ; it contained a small artery and cartilage resembling that of an ear. The occurrence of such supernumerary ear-like formations in the neck will be easily understood if it is remembered that the second branchial cleft furnishes material for individual parts of the external ear. These outgrowths may increase after birth, but their development is slow. Zahn found young cartilage-cells in the surrounding perichondrium next to fully developed cartilage, which explains the increase in size that takes place. It must not be forgotten that under these conditions a branchial enchondroma may develop as the result of extremely active growth. Treves reports a case of this sort.

The malformation is annoying to the individual only when it is of considerable size ; in itself it causes no symptoms.

epithelium, which often becomes changed in the central portion of the tract (ductus lingualis) to ectodermal squamous epithelium; and in the peripheral section—*i. e.*, from the end of the canal to the opening in the skin—ectodermal squamous epithelium is frequently found. The observations in Bergmann's clinic indicate the greater prevalence of median fistulæ, contrary to former statistics which seemed to show a marked predominance of the lateral variety.

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The growth is excised usually on account of the disfiguration of the patient. This may be done without misgiving, considering the superficial situation.

TERATOMA.

The 9 cases of teratoma of the neck so far reported are of bigeminal origin, for all contain organs or rudiments that are not to be explained in any other way. In all probability they are caused by fœtal inclusion of a partially developed ovum in the branchial cleft. Very little is known about the relation of these tumors to the branchial cleft, for there have been as yet no topographical or anatomical investigations on this subject.

Symptoms.—Clinically, a teratoma presents the appearance of a fairly large-sized tumor in the lateral or anterior region of the neck corresponding to the position of a goitre, having a somewhat irregular surface, hard in some places, soft in others. The overlying skin is normal and movable. On swallowing, the tumor may move up and down, and dyspnœa may be produced by its displacement and compression of the air-passages. The tumor frequently increases in size after birth.

Diagnosis.—The diagnosis is difficult, because it is at times hardly possible even microscopically to distinguish the growth from struma congenita; it may be confounded with the latter as well as with congenital cysts.

Treatment.—Excision has been followed by cure in 3 cases. It is the only method of treatment worth considering, and the prospects, with proper asepsis, are good, inasmuch as children born with this deformity are usually otherwise healthy.

CERVICAL RIB.

This congenital malformation has, since the publication of G. E. Fischer, but recently attracted the attention of surgeons. Anatomists not infrequently find this condition. Pilling collected 140 cases from literature in 1894, but those since reported are few in number—about 20 observations. The fact that a cervical rib is attended by symptoms only in individual cases is the reason why it is observed so infrequently in clinical work.

The supernumerary rib is always in contact with the seventh cervical vertebra and is usually joined to it. The degree of development varies; sometimes the rib does not reach beyond the transverse process, but may be considerably longer in other cases. The end is either free or joined tightly to the bone of the first thoracic rib (bony or fibrous), and in rare cases it reaches to the cartilage of the first rib, or even to the breast-bone, and is then joined to the latter by cartilage. Post mortem this malformation is more common on both sides, but in the living, according to present observations, it is found more frequently on one side. The occurrence of a second cervical rib in relation with the sixth vertebra is a great rarity, inasmuch as but 2 cases have as yet been reported. (Struthess, Karg.) The relation of the rib to the subclavian artery and the branchial plexus is the main point of interest, as almost all the clinical symptoms are referable to these structures. The subclavian artery always takes its course over the cervical rib to the first dorsal rib, or when the former is but slightly developed the artery runs in front but never below it. The vessel is usually situated in a groove on the upper surface of the rib. In its course over this abnormal bony arch the artery is pushed up nearer to the surface. This change of position may easily lead to compression or laceration of the vessel. The branchial plexus situated behind the artery may be subjected to pressure and traction on the part of the rib. The scalenus anticus is frequently inserted into the anterior edge of the rib, and the medius may be inserted into the cervical rib and at the same time into the first dorsal rib. The space between the first dorsal rib and the cervical rib is filled out by intercostal muscles.

Symptoms.—A cervical rib primarily causes no disturbance, is usually found accidentally, and symptoms are produced only secondarily by changes in the circulation or some nervous disturbance. The amount of circulatory disturbance caused by compression of the subclavian artery may vary considerably, in some cases weakness of the radial pulse being all that is observed; in others thrombosis may occur, extending either from the subclavian to the periphery or but a short distance. Aneurism of the subclavian has also been frequently noted. The clinical signs of disturbance are diminished temperature of the extremity and pallor of the hand and arm; only 2 cases of gangrene of the fingers have as yet been reported. (Cooper, Hodgson.) Usually collateral circulation is established before thrombosis develops. Disturbances in the branchial plexus affecting the sensory areas are manifested by neuralgic pains that spread over the arm or are confined to some particular region. Paræsthesia may be present, as itching, "pins and needles," numbness, or a sense of weakness and general tire may be complained of. The function of the arm may be considerably affected by these conditions; motor power is ordinarily not much influenced. Paralysis has not been observed, although diminution of the electrical irritability of nerves and muscles has been reported. (Bernhard, Tilmann.) Symptoms appeared between the fifteenth and sixtieth year in the cases reported to date. In 2 cases (Karg, de Quervain) pressure from the strap of a knapsack was the local cause; in another case (Hirsch) periostitis of the supernumerary rib caused the sudden appearance of secondary symptoms. Attention is probably more frequently called to the condition in connection with inflammatory processes. The local condition is as follows: Instead of the normal depression above the clavicle, there is an angular fulness which pulsates visibly. Palpation shows that the fulness and pulsation are produced in the course of the subclavian artery by a bony swelling about a finger's length above the clavicle, reaching from the seventh cervical vertebra to the first dorsal rib, and ending free or bound down to the latter. This bony prominence is immobile, painless, and covered with normal skin. If the cervical rib is short, and the artery is placed in front of it, fulness and pulsation may be absent. Marked muscular development or fat may render it difficult to obtain more accurate knowledge.

Diagnosis.—The diagnosis is usually easy, and a differential diagnosis lies between this condition and exostosis of the first rib, which is not uncommon and produces very similar symptoms. Nervous symptoms in both conditions are identical, but the circulatory disturbances differ. The exostosis usually presses less upon the artery, but is more apt to compress the vein and cause secondary œdema of the arm, a condition which has not been reported in connection with a cervical rib. The bony consistency of the rib will in all probability prevent confounding with tumors of the supraclavicular fossa (tuberculous glands), at times giving rise to nerve symptoms on account of adhesions. In doubtful cases the *x*-ray will give valuable diagnostic aid. In one patient it was possible to demonstrate the presence of a cervical rib before operation; a similar condition on the other side had produced no symptoms.

Prognosis.—The prognosis is favorable, as grave disturbances of the circulation eventually disappear. Thrombosis is usually avoided by the formation of collateral circulation. Aside from slight gangrene of the finger-tips, disturbances of nutrition have not been reported. Aneurisms have usually been cured or remained stationary. Neuralgia and paræsthesia have generally improved under palliative treatment and disappeared rapidly after resection of the rib.

Treatment.—By massage and electricity and non-use of the arms the discomfort of the patient may be much alleviated or removed. The safest way to effect a cure is to remove the cause by resection of the supernumerary rib. The results of this procedure are extremely favorable, and in all of the 10 or 12 cases operated on to date disappearance of discomfort and disturbances has been complete.

OPERATION.—The operation is difficult and not without danger, owing to the topography of the affected region and the proximity of the pleura, which often reaches close to the cervical rib, and has been frequently injured, but always without serious harm to the patient. The rib is exposed by the usual incision for ligation of the subclavian artery; the artery and nerves are retracted to the inner or outer side, the muscles are divided, and the rib resected with forceps or wire saw as near as possible to its seat of attachment. It is advisable to remove the periosteum as far as possible, to avoid recurrence. When the pleura is torn, pneumothorax is prevented by tamponing as rapidly as possible, and subsequent admission of air is prevented by closing the wound accurately with deep or buried sutures.

DISEASES OF THE STERNOMASTOID.

Muscular Wry Neck (Caput Obstipum), Congenital or Developing soon after Birth.—By muscular wry neck is meant the faulty position of the head produced by a shortening of one of the sternomastoid muscles.

Etiology.—It is doubtful whether torticollis should be classed with diseases of the neck, because the etiology is as yet unknown. Three theories are advanced to explain its origin, none of which is beyond criticism. According to the oldest theory—that of Stromeyer, which recently has been energetically defended by Witzel—the shortening of the muscle in the majority of cases is due to injury to the muscle at birth. This traumatic origin, accepted up to 1884, has been disputed by Petersen, who claims that wry neck is always congenital. The more recent view of Mikulicz and Kader is that wry neck is never congenital, but is due to hæmatogenous inflammation of the muscle secondary to a local deposit produced by injury at birth.

The following data are in favor of the traumatic theory:

1. Statistics prove that labor is difficult in a large percentage of children born with wry neck, and that they are either breech presentations or instrumental deliveries. Of 43 cases collected by Witzel, 25 were delivered by artificial means (version, traction, or forceps).

2. It has been demonstrated beyond question that laceration of the sternomastoid may be caused by traction. Post-mortem examinations of the newborn show that any degree of muscular laceration is possible from microscopical tears up to complete rupture on one or both sides. (Fahsbender, Skrzeczka, Ruge.) Ruge found hemorrhages in the sternomastoid, or in the vicinity, 18 times in 64 cases of artificial delivery.

3. The experiments of Küstner have shown that no great degree of force is necessary to produce tearing of muscles, and that even rotation of the head in spontaneous delivery may be sufficient.

4. A swelling or hæmatoma in the sternomastoid develops as a result. The swelling, at first soft, gradually becomes harder, even as hard as cartilage. In a small percentage of cases this swelling of the sternomastoid is followed by permanent wry neck, but in the majority of cases it disappears without leaving trace. This fact would seem to indicate that the swelling is produced by an effusion of blood which is gradually absorbed.

The following facts are opposed to the traumatic theory:

1. Although post-mortem examinations have shown that bilateral injury to the sternomastoid may occur, shortening of the muscle is always unilateral (only 1 case of congenital bilateral caput obstipum has as yet been reported, by Hildebrand, 1897).

2. Wry neck is very rare compared with the frequency of injury to the sternomastoid during delivery.

3. Shortening of the muscle after tearing or bruising is contrary to general experience, for, as a rule, lacerated muscles heal without change in length.

4. Microscopical examinations of the shortened muscle made soon after birth have never showed evidence of injury; on the contrary, it has been demonstrated that the swelling of the sternomastoid usually

called hæmatoma is produced by extensive new formation of connective tissue without trace of blood-pigment. (Petersen, Köster, Hildebrand.)

Following are the positive reasons for considering wry neck of a congenital origin:

1. There are cases of congenital wry neck in which injury to the muscles at birth can be excluded.
2. Congenital wry neck, the occurrence of which is admitted by Stromeyer and Witzel, has been demonstrated post mortem. Petersen has added 9 additional observations to Heusinger's case, in which marked shortening of the muscle was present in an infant only one day old.
3. Microscopical examination of specimens from infants four to eight weeks old, with shortened sternomastoids, showed fibrous degeneration that could only be explained by intra-uterine processes.
4. Heredity of the affection has been repeatedly demonstrated.
5. Unilateral occurrence of the deformity.

The origin of intra-uterine shortening of the muscle is unknown. Habitual side position of the head in utero, amniotic adhesions, early fixation of the head in the pelvis, etc., have been offered in explanation. The reasons advanced against the congenital theory do not seem to be sound. Faulty position of the head may be the cause of difficult labor, and during delivery injury may occur as well to such a shortened and degenerated muscle as to a normal muscle.

Advocates of the most recent theory assume that shortening of the muscle is produced by inflammatory processes. According to Mikulicz, wry neck is at times congenital as a result of inflammation in utero, but is more frequently of post-partum origin due to myositis produced by injury to the muscle during delivery. Kader claims that torticollis may be of intra-partum or post-partum origin, but that it is rarely the result of injury to the muscle alone or of inflammation alone. In the majority of cases he believes that there has been a combination of trauma and inflammation. The bruised muscle furnishes favorable soil for bacteria which, having reached the seat of trouble from the intestinal canal by way of the blood, cause acute myositis. This myositis may vary in intensity, and may disappear without leaving any trace, but on account of its chronic progressive course is more frequently followed by shortening of the muscle. Mikulicz's views are based chiefly on the results of microscopical examinations in 21 cases of wry neck where the muscle was partially or totally excised. In all of these cases changes were present even in parts of the muscle that macroscopically seemed normal, and were always characterized by substitution of new formed scar connective tissue for muscle-tissue, which had contracted upon the muscle-fibres and destroyed them. These presented either an appearance of atrophy (rest stage) or of acute disease, as indicated by swelling and irregularity of the fibres, loss of transverse striae, cloudiness of the plasma, abundant growth of granulation-cells, and abundant new formation of blood and lymph-vessels. All grades of variation were to be found between the state of rest and acute dis- Inflammatory changes could always be demonstrated in the vicinity of the affected sternomastoid. There was union of the muscle to its sheath and to the surrounding muscles, thickening of the neighboring connective tissue of the carotid sheath, fibrous degeneration of the longus colli, omohyoid, etc., and, finally, hyperplasia of the lymph-glands in the vicinity.

The evidence against hæmatogenous origin of myositis is as follows:

1. In spite of bilateral injury to the muscles, contraction is always unilateral.

2. The acute stage of the disease has not been demonstrated microscopically during the first days or weeks post-partum.

3. The infection assumed to occur has not been demonstrated.

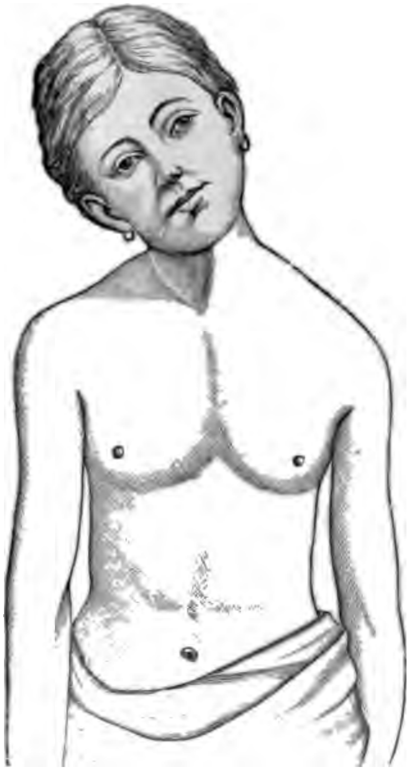
At the present time the facts bearing upon the etiology seem to indicate that wry neck is of congenital origin. The intra-uterine processes that may be the causes are unknown. It cannot be denied that there may possibly be besides the congenital variety acquired wry neck produced by trauma or inflammatory processes. The clinical picture, usually so uniform, would, on the other hand, be in favor of a uniform etiology. It is easily conceivable that the muscle-changes produced before birth may become more extensive, due to injury at birth or subsequent inflammation.

The etiology of wry neck is not yet certain, and a final decision is to be expected only from early microscopical examination of a large number of cases.

Anatomy.—The sternomastoid is usually more or less contracted. Sometimes it is only half its normal length and is usually much diminished in size. In some cases the color and consistency are normal; in others the muscle is tendinous in places or appears as a tough, tendinous strand throughout its length. The sternal portion is more frequently involved than the clavicular. Even in severe cases of wry neck there may be no changes whatever in the muscle-substance. There may be, however, thickening of the muscle- and vessel-sheaths, aponeurotic adhesions, and fibrous degeneration of the neighboring muscles (trapezius).

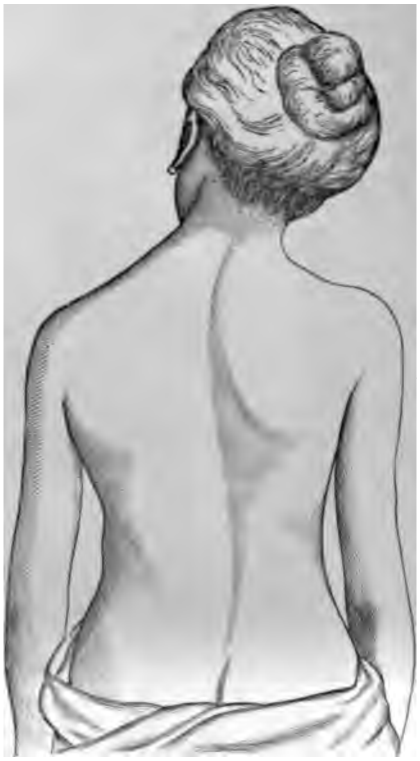
Typical secondary changes are found in the remaining soft parts of the neck, also in the skull and vertebral column. These have been clearly demonstrated by Witzel's post-mortem observations. In left-sided wry neck the left sternomastoid appears as a round, dense, almost vertical strand, which stands off from the vertebral column. The cervical vertebræ always form an arch with the convexity to the right side, across the middle of which the right sternomastoid lies as a broad, flat, tense band. On the right side the large vessels are spread out side by side; while on the left side they are little visible. The jugular vein is more apt to lie in front of than behind the carotid. There is, as a rule, no difference in the thickness of the walls nor in the lumen of the vessels. The other muscles of the affected side, besides the sternomastoid, also show some change in their course. The changes in the bones—due in part to traction of the shortened muscle, in part to the effort to compensate faulty position—lead to scoliosis of the cervical vertebræ with the convexity to the healthy side (in left wry neck, to the right). There is also scoliosis of the dorsal and lumbar column (in left-sided wry neck, dorsal curve to the left, lumbar curve to the right). With considerable lordosis the cervical vertebræ show much anterior deformity. The shape of the vertebræ changes corresponding to the curve and direction of the articular surfaces. The other changes in the vertebral column of the chest and lumbar region correspond to those of ordinary scoliosis. The asymmetry of the skull and face, which has been studied with particular care by Witzel, is of especial interest. In left wry neck the middle line of the skull as seen from below forms a curve to the left side. The facial part of the skull on the right side is depressed and drawn back and to the left, while its base is narrower on the right side than on the left. The greatest convexity of the skull does not correspond to the median line, but rather to a line from the right frontal eminence diagonally backward to the left. The right diagonal diameter is larger than the left, and the right frontal and left occipital regions are especially prominent. The skull appears compressed in the direction of the right diagonal diameter, and

FIG. 3.



Muscular wry neck: front view. (Hoffa.)

FIG. 4.

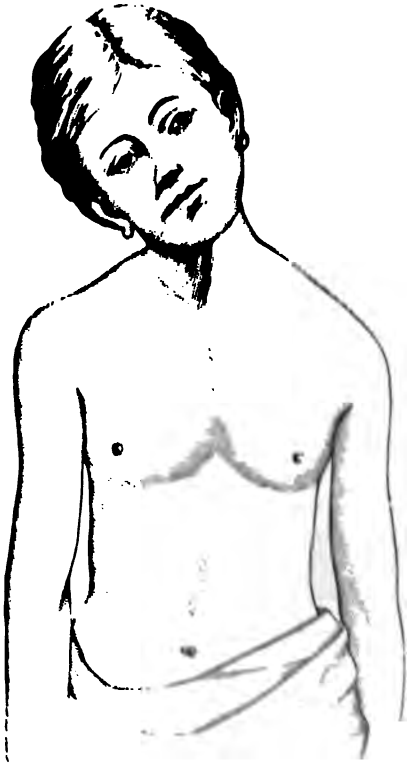


Muscular wry neck: back view. (Hoffa.)

is therefore narrower on the right half than on the left. The left (affected) side of the face is lower and broader; the right (healthy) is narrower and longer. The former is prolongated downward. The symphysis of the lower jaw is displaced to the left. The left half is therefore shorter, but at the same time thicker than the right, which is longer and thinner. The angle of the jaw on the right side is about 120 degrees; on the left side, 90 degrees. The soft parts and bone of the affected side show more or less pronounced atrophy. The changes in the skull and face corresponding to scoliosis of these parts with the convexity to the healthy side depend on asymmetrical growth, the cause of which has not as yet been found. In all probability it is produced by a combination of causes, among which may be mentioned unequal bearing of weight and altered line of traction of the muscles attached to the jaw and base of the skull.

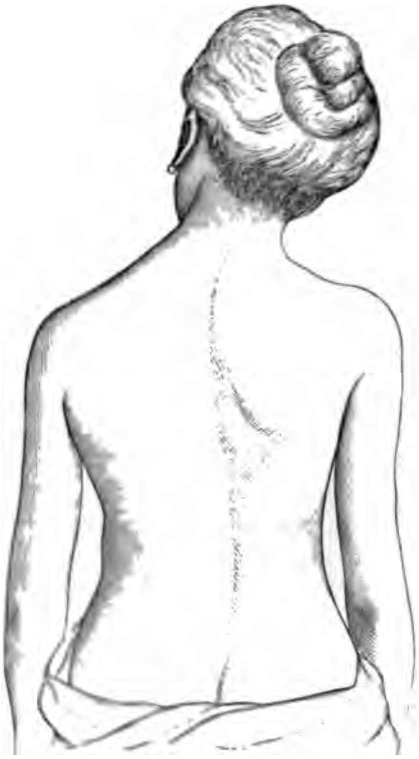
Symptoms.—The head is drawn very distinctly to the side on which is the shortened muscle—for instance, to the right side—and the face at the same time is turned toward the healthy side, to the left. When attempts are made to correct the position of the head, the shortened muscle stands out like a cord. The skin of the affected side of the neck sometimes shows transverse folds. The carotid pulse on the affected side can be felt only indistinctly, deep beside the tense muscle; whereas on the healthy side it is quite superficial and easily found. Extension and rotation of the head toward the affected side are limited, although attempts at motion cause no pain. The abnormal position of the head is not the same in all cases, which leads Lorenz to distinguish two types of wry neck—simple and complex. In simple wry neck the head is carried toward the affected side, so that this side shows marked lateral deviation; for instance, to the right shoulder, with slight rotation to the left. The entire head is displaced from the middle line to the side of the deviation. The cervical vertebræ are convex toward the healthy side, therefore toward the left side, and the thoracic vertebræ also show curvature to the left. There is therefore dorsocervical scoliosis to the same side. In the second variety the deviation of the head to the affected side is much less. Rotation toward the healthy side is much more marked. (Fig. 5.) The ear of the affected side seems lower because the shoulder of this side is elevated. The head *in toto* is displaced toward the healthy side. There is cervical scoliosis to the healthy side, but dorsal scoliosis to the opposite side. The simple form (cervical scoliosis without occipital compensation) is the primary type corresponding to the early stages of wry neck. This may remain as such permanently, but it usually changes to the complicated variety when the children begin to hold themselves erect. The asymmetry of the face usually present varies in degree, that half of the face corresponding to the side affected being lower and broader than the other; the distance of the angle of the mouth from the external angle of the eye is less. A line drawn through the external angles of the eyes and one through the angles of the mouth converge toward the affected side. Wry neck is more common on the right side vertebræ with the convexity to the healthy side (in left wry neck, to the right). There is also scoliosis of the dorsal and lumbar column (in left-sided wry neck, dorsal curve to the left, lumbar curve to the right). With considerable lordosis the cervical vertebræ show much anterior deformity. The shape of the vertebræ changes corresponding to the curve and direction of the articular surfaces. The other changes in the vertebral column of the chest and lumbar region correspond to those of ordinary scoliosis. The asymmetry of the skull and face, which has been studied with particular care by Witzel, is of especial interest. In left wry neck the middle line of the skull as seen from below forms a curve to the left side. The facial part of the skull on the right side is depressed and drawn back and to the left, while its base is narrower on the right side than on the left. The greatest convexity of the skull does not correspond to the median line, but rather to a line from the right frontal eminence diagonally backward to the left. The right diagonal diameter is larger than the left, and the right frontal and left occipital regions are especially prominent. The skull appears compressed in the direction of the right diagonal diameter, and

FIG. 3.



Muscular wry neck: front view. (Hoffa.)

FIG. 4.

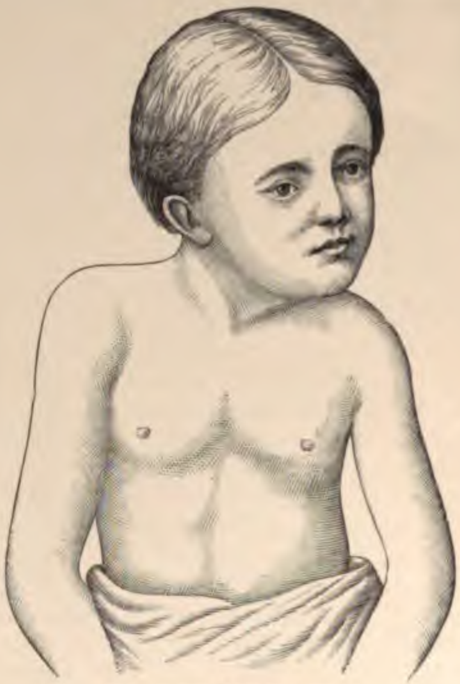


Muscular wry neck: back view. (Hoffa.)

than on the left, and is sometimes noticed immediately after birth, but oftentimes only when the children begin to stand and walk. Sometimes the condition remains almost stationary for years, while in other patients the deformity increases noticeably with the growth of the child.

Diagnosis.—The diagnosis offers no difficulties, for the clinical picture is characteristic. There may be doubt as to the origin, especially when the history is incomplete. In the differential diagnosis other types of wry neck will have to be considered.

FIG. 5.

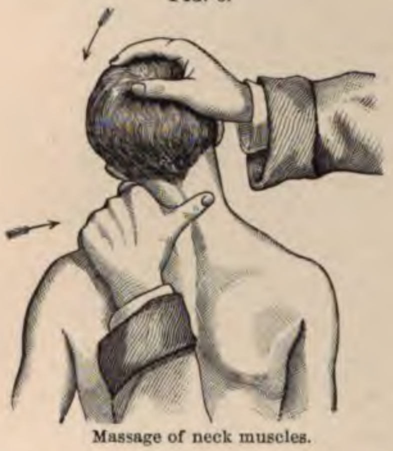


Muscular wry neck. (Hoffa.)

Prognosis.—As the affection is purely local, the prognosis is favorable as far as the general health is concerned, but not so as regards the deformity, for there is oftentimes marked tendency to increase, especially during the growing period.

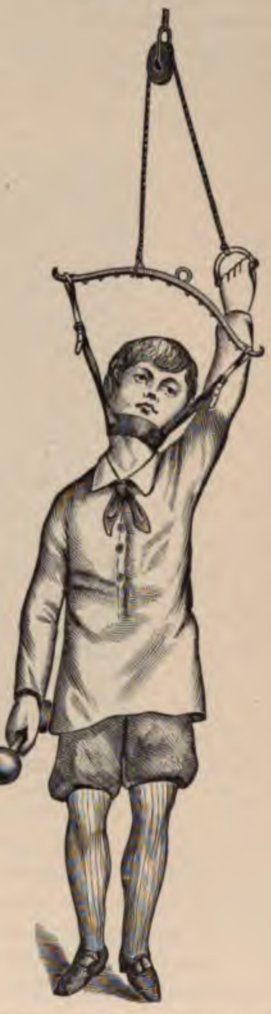
Treatment.—The treatment has of late advanced considerably as a result of the progress made in orthopædics. Experience shows that the deformity can be completely eradicated if suitable measures are adopted in the early stages. Treatment should be begun upon the infant as soon as a diagnosis has been established. It consists of light massage of the affected side of the neck and correcting motions that are intended to bring the head little by little toward the healthy shoulder. (Fig. 6.) When the child is somewhat older, the corrected position may be permanently maintained by means of Glisson's sling. If traction is made on one side of the sling, the tendency will be to bend the head toward the healthy side. Counterextension is made on the affected shoulder. (Fig. 7.) Sometimes it will be of advantage to apply a stiff bandage—for instance, a felt or leather collar that has been shaped over a plaster cast. In slight cases complete cure may be obtained within a few months if these directions are faithfully followed. When the patient comes for treatment in the second or third year, the deformity is more marked, but massage and orthopædic appliances must be first utilized before attempting radical removal of the cause—*i. e.*, the muscular shortening. This can be done by three methods of operation: 1. Subcutaneous tenotomy (Stromeyer); 2. Open division of the muscle (Volkmann); 3. Excision of the sternomastoid (Mikulicz). Since the introduction of asepsis subcutaneous tenotomy is no longer recognized as a justifiable operation. It is applicable at present only in exceptional cases. If done thoroughly, there is life-endangering risk to the jugular vein. The sole advantage is the avoidance of a scar. Should division be only partial, the result will be correspondingly unsatisfactory. The surgeon who expects to obtain a radical result will rarely use a tenotome. The most rational method is open tenotomy as introduced by Volkmann. The skin incision is vertical, transverse, or diagonal. The scar, which is the only disadvantage of the method, is

FIG. 6.



Massage of neck muscles.

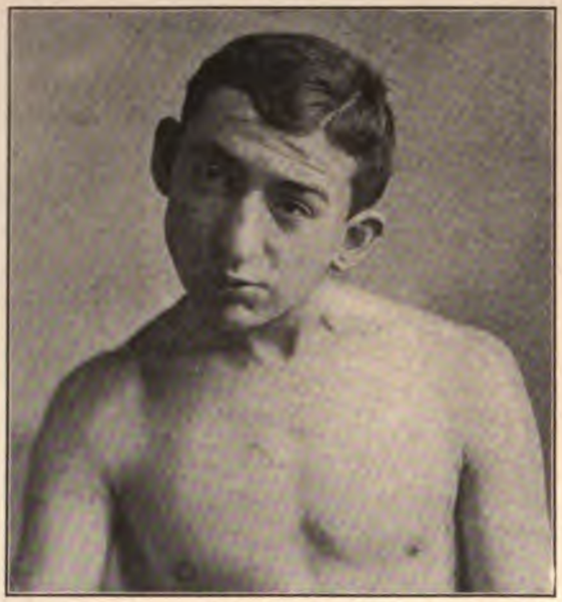
FIG. 7.



Glisson's sling for applying counterextension to the shoulder.

least noticeable according to Lorenz, if the incision is made between the clavicular and sternal portion of the muscle. It is well to begin at the sternal margin and carry the incision upward and outward for about 2.5 to 3 cm. toward the internal margin of the clavicular portion. By displacing the overlying tissues both portions of the muscle may be made to present in the wound one after the other, and may be divided. The head, placed on a pillow, is pulled to the healthy side with considerable force, counterextension being made at the same time on the shoulder of the affected side. All tense bands are divided down to the bulbus jugularis. The operator must determine by touch whether all of these bands in the wound have been divided or not. After the hemorrhage is stopped, the skin-wound is closed with a few sutures and an aseptic pressure-bandage applied. While the patient is still under the anæsthetic the stiff bandage is put on in the following way (Lorenz): An assistant holds the forehead and occiput of the patient with both hands. The head is gradually drawn to the healthy side by rotation around the sagittal axis, and after it has been bent completely over four fingers of each hand are placed on the cranial portion of the scoliosis, while both thumbs are placed in front and behind the ear on the concave side. The cervical vertebræ are now bent toward the affected side until the ear of the convex side can be placed on the corresponding shoulder, intermittent gradually increasing force being applied. Direct pressure on the head from above increases the curve of

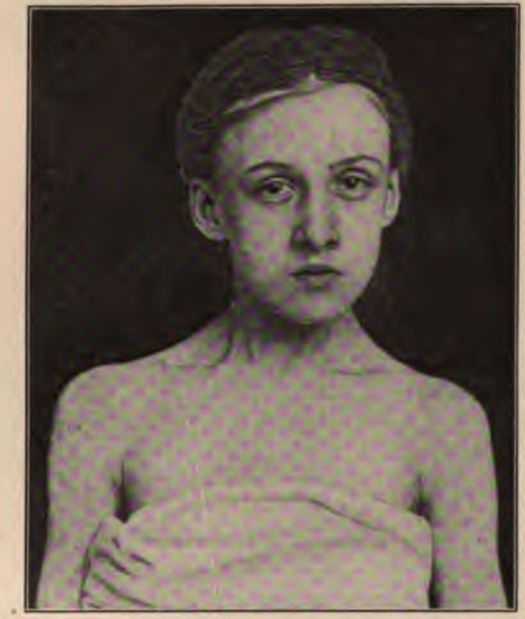
Fig. 8.



Left torticollis, apparently of congenital origin, showing the secondary distortions of head and face. (Whitman.)

the cervical vertebræ considerably. When the cervical column is very stiff, this process of bending requires considerable force and patience. Rough application of force must be avoided in view of the danger of tearing vessels and nerves, especially since a fatal case has been reported by Reiner. The head is held in the overcorrected position for ten to fourteen days with a stiff bandage that includes the chest. After removal of the bandage the subsequent treatment consists solely in active bending of the cervical vertebræ, which can usually be done by the patient at once. Lorenz has obtained a permanent cure in 15 cases by this method. As the divided ends of the muscle retract on bending the neck after operation, and are separated some distance from each other, a recurrence is improbable provided the directions given by Lorenz are implicitly followed. Lorenz considers tenotomy only a preliminary step, and regards correction of the cervical scoliosis the chief object of radical treatment. Mikulicz, on the contrary, maintains that complete obliteration of the primary cause is most important. He removes the sternomastoid and considers orthopædic after-treatment unnecessary. Mikulicz recommends excision of the muscle as the surest means of preventing recurrence in all cases of wry neck. The muscle is exposed by a longitudinal incision commencing between the sternal and clavicular portions. After division of the lower insertion the muscle is dissected out partly with the knife, partly by blunt dis-

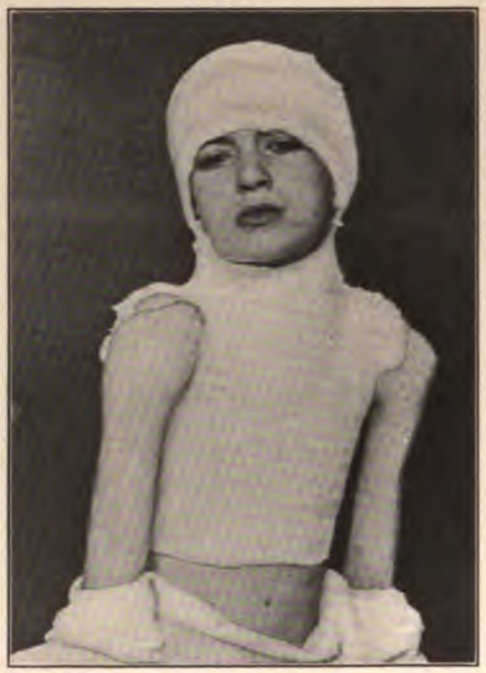
FIG. 9.



Right torticollis, showing the displacement of the head toward the opposite side. (Whitman.)

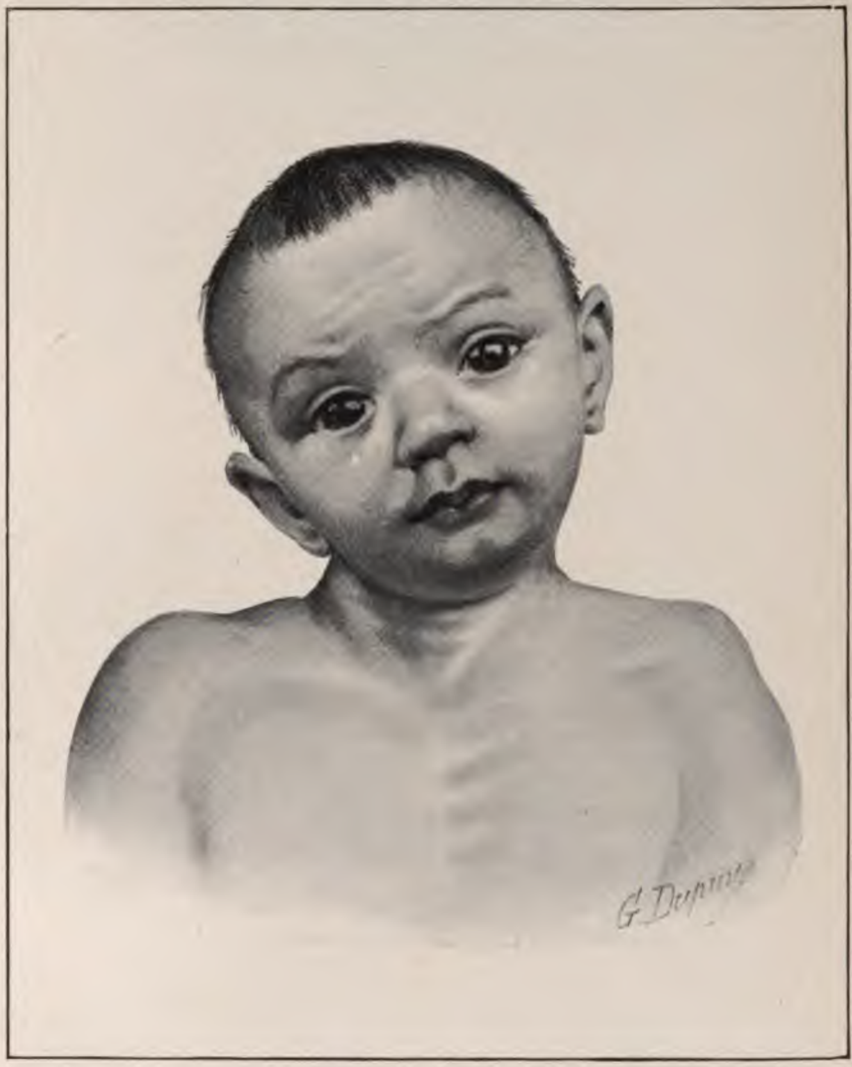
section. Only the lower two-thirds are excised, so as to preserve the spinal accessory nerve. After division of all tense bands in the vicinity the wound is closed and a pressure-bandage applied. A moderate amount of bending of the neck may be done after the operation, but is unnecessary, as is any other orthopædic after-treatment, because the scoliosis improves spontaneously. Hoffa and v. Bruns corroborate these statements on the strength of practical experience. Bruns limits excision to the lower tendinous third, and makes a transverse skin incision. In slight cases Mikulicz considers subcutaneous tenotomy near the clavicle, with orthopædic after-treatment, the normal procedure, and condemns open incision. It is justifiable to advise excision of the muscle because recurrences after division are due to extension of the myositis, leading to reproduction of the deformity. There seems to be no question that the chances of obtaining a complete cure are greater after removal of the muscle than after tenotomy. It is unnecessary, however, to undertake this radical step, because the results of milder methods of treatment—especially that of Lorenz —seem to be quite satisfactory. Furthermore, excision of the muscle cannot be recommended on account of the cosmetic effect, and should be confined to those cases in which careful orthopædic after-treatment does not seem possible, or in which recurrence has followed the most careful treatment.

FIG. 10.



Left torticollis, showing the method of fixing the head in the overcorrected position. After operation. (Whitman.)

PLATE I.



Hæmatoma of the Sternomastoid Muscle of the Right Side in a Newborn Infant. Swelling at the centre of the anterior border of the muscle; contraction of the muscle with torticollis. (Koplik.)

Other Types of Wry Neck.—Aside from the cases of wry neck already described depending upon congenital contracture of the muscle, or contracture appearing soon after birth, there is a series of acquired cases due to a variety of causes. Taking the etiology into consideration, these may be subdivided into dermatogenic, myogenic, neurogenic, and arthrogenic wry neck. Clinically they are acute or chronic.

Dermatogenic contracture is caused by extensive scarring of the skin and subcutaneous tissue, and takes place after injuries to the skin produced by burns or ulcerative processes (tuberculosis, syphilis). Scar-contraction may also take place and produce wry neck after destruction of the cervical fascia following suppuration. The diagnosis in the cicatricial type is so evident that it is hardly possible to confound it with other varieties. A cure can be obtained only by operation—*i. e.*, by excision of the scar-tissue and plastic repair of the deficiency.

Myogenic contractures may be produced temporarily by acute muscle-changes and permanently by chronic processes. The temporary affection is usually a sequence of rheumatic disease of the sternomastoid. After catching cold the patient awakes with sharp pain on one side of the neck and has a "stiff neck" on that side. The muscle is tense, and tender to pressure, and motion is painful. With proper treatment, immobilization of the head and poultices, convalescence usually takes place within a few days; only rarely does the condition become chronic. Permanent contraction is due to fibrous degeneration following myositis, and is apt to develop after acute infectious diseases, such as scarlet fever, measles, typhoid, or syphilis. The diagnosis of torticollis rheumatica is easily made, as the clinical picture is characteristic, and in the type produced by myositis the history will prevent confounding with typical muscular wry neck.

Neurogenic contraction may be produced by reflex action, spasm, or paralysis. Reflex torticollis is observed especially in acute inflammatory painful processes, such as deep-seated suppuration and abscesses when the patient tries to diminish tension on the inflamed tissues by turning the head. In these cases the contraction is frequently secondary to direct irritation of the muscle, which has become inflamed. Spastic torticollis begins as clonic contractions of the sternomastoid produced by irritation of the accessorius (neuritis, meningitis, tumors), or by central disturbances in the head-rotating region of the cerebral cortex (de Quervain) sometimes due to general neuroses. Very rarely wry neck is due to paralysis of the sternomastoid, which in turn is a paralysis of the accessorius. The healthy muscle of the other side acquires the balance of power and pulls the head to that side. Paralysis of the nerve may be produced by central or peripheral causes. Among the latter may be mentioned injuries to the neck, inflammation, tumors, and affections of the vertebræ. There is usually no difficulty in making a *diagnosis in the neurogenic type*. The treatment of reflex torticollis is the treatment of the disorder that gave rise to it. It has been attempted to prevent the clonic and tonic spasms by operation, especially by resection of the spinal accessory nerve, and recently by division of the sternomastoid and other muscles taking part in the spasm. (Kocher, de Quervain.)

Typical wry neck may be differentiated from that occurring in the course of cervical Pott's disease by careful examination. Aside from the history and absence of rotation of the chin to the opposite side, the characteristic symptoms of vertebral inflammation (neuralgic pains, pain on pressure over the affected vertebræ, stiffness, and swelling) will enable a correct decision. The differential diagnosis between rotation subluxations of the cervical vertebræ is more difficult because the position of the head corresponds to that of typical wry neck. Nevertheless consideration of the origin and the presence of other signs of injury will probably always lead to a correct diagnosis.

Syphilis of the Sternomastoid.—Of the muscles of the neck, the sternomastoid is about the only one affected by syphilitic changes.

Symptoms.—The disease is manifested either as diffuse sclerotic myositis or more frequently as a gummatous swelling which begins in the interstitial tissue. Nodes of considerable size develop with corresponding disappearance of the muscle-substance. After some time these masses coalesce and break externally, producing ulcers. They are usually situated in the lower third of the muscle and are not infrequently symmetrical, and as long as they are confined to the muscle they produce, as a rule, no disturbance of function and are not painful.

Typical observations have been reported by Bramann, Dunn, Guttmann, Eger, and Honsell.

Treatment.—Treatment consists in administration of potassium iodide, the favorable action of which confirms the diagnosis.

DISEASES OF THE HYOID BONE.

Fractures of the Hyoid Bone.—Fractures of the hyoid are very uncommon, for the bone is but little exposed to outside forces and it is very elastic and movable. The break may be produced by direct or indirect violence. In the first class of cases the body of the bone is usually affected; in the latter cases the horns are pressed together laterally or spread apart by being forced against the vertebral column and break off. Direct fracture may be due to a fall, a blow, or to hanging; indirect fracture is produced by strangling especially. There is usually considerable displacement of the fragments, which may lead to injury of the pharyngeal mucous membrane.

Symptoms.—The symptoms are characteristic. At the seat of fracture there is violent pain, which is increased by movement of the bone. Swelling, interference with swallowing (dysphagia valsalvæ), difficulty in talking, dyspnœa, and a tendency to cough are also present. Injury of the pharyngeal mucous membrane and bleeding from the mouth may occur as a result of displacement of the great horn.

Diagnosis and Treatment.—The diagnosis is easily made by bimanual palpation, which at times detects crepitation. Replacement of the fragments is accomplished in the same way by pressure from within out. By immobilization of the head and neck by means of extension or with a stiff collar the fragments of the bone are kept in place until they unite. When there is marked difficulty in swallowing, it may be necessary to use a stomach-tube, and dyspnœa may demand tracheotomy. A callus develops as a rule during the process of healing. Noble in one case was obliged to excise the great horn after a few weeks because of lack of union, the patient being annoyed by a sensation as of a substance sticking in his throat.

Inflammations of the Hyoid Bone.—Stetter reports a case of primary acute periostitis of the hyoid. A painful abscess about the size of a walnut developed over the body of the hyoid following injury. After this had been incised, the bone was seen to be bare of periosteum and very rough (recovery.) Ullmann recently reported a case of caries of the hyoid with subsequent fistula in a man aged forty years. The fistula remained after incision of a small abscess on the right side of the neck four years previously; the necrotic portion of bone was resected. Syphilis is rarely manifested in the hyoid bone. Elliott observed 5 such cases which had marked pain on swallowing or speaking, or whenever the head and neck were suddenly moved. These symptoms were found to be due to one or more periosteal nodes of the hyoid alone or associated with chondritis of the thyroid cartilage.

Tumors of the Hyoid Bone.—Only 2 cases of primary tumor of the hyoid are reported in the literature. In one case, operated on by Böckel, a chondroma with cyst-formation developed on the surface of the great horn. This growth was about the size of two fists and was in close relation with the large vessels of the neck. There was interference with swallowing. It was excised with difficulty after resection of the great horn. The patient died one week afterward from secondary hemorrhage. A second observation, recently published by Spisharny, was the case of a man aged twenty-five years, with a tumor about the size of a hen's egg that had gradually developed during the last five years and given rise to marked hoarseness and difficulty in swallowing. This was a chondroma on the inner side of the right greater cornu, which pressed upon the lateral wall of the pharynx and pushed the thyroid cartilage to the left. Excision was followed by complete recovery.

CHAPTER II.

INJURIES OF THE NECK.

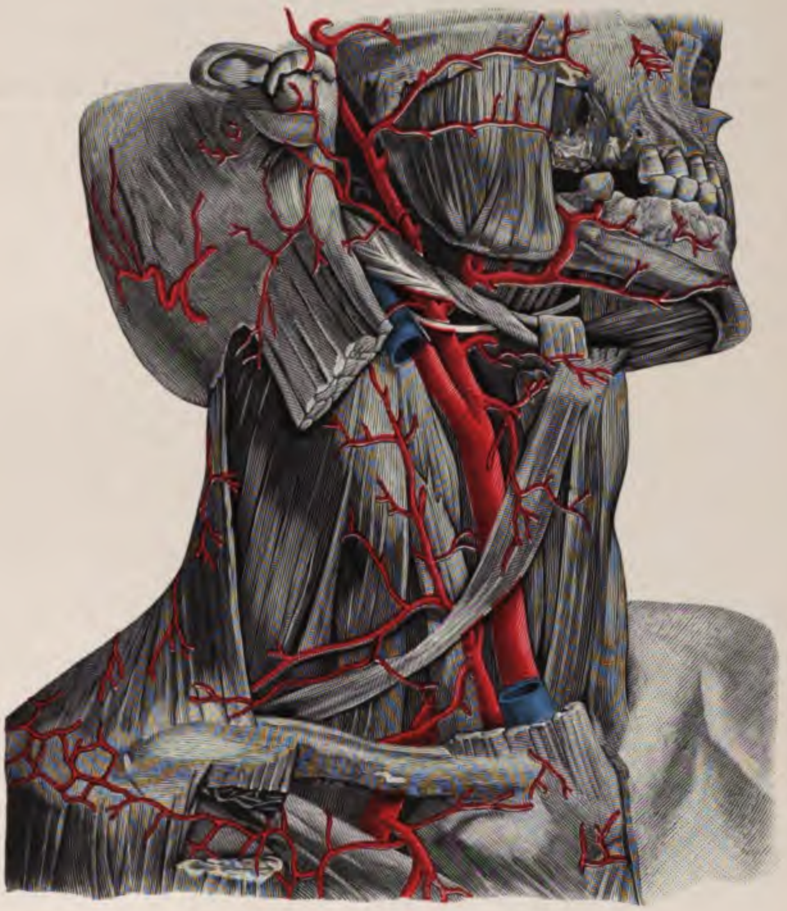
INJURIES OF ARTERIES IN THE NECK.

Symptoms.—The chief symptom of arterial injuries in the neck is hemorrhage, which may be external, internal, or intercellular. When there is an extensive incised external wound, the blood of an artery is usually poured out through the incision. If an adjoining cavity is opened at the same time—for instance, the trachea, or the pleural cavity—a portion of the blood may flow into it. Hemorrhage takes place into the tissues when the skin-wound is very small, or is occluded by a clot or a foreign body, or when the artery affected is at a considerable distance from the external wound, as in a case of stabbing; and, finally, if the wound in the vessel has been produced by some force acting from within, such as results when a vessel is punctured by a fragment of bone, for example, the clavicle or first rib.

Injuries to arteries are most frequently produced by stab- or gun-shot-wounds. In incised wounds, made for suicidal purposes, the vessels usually escape the knife because the trachea and œsophagus are rendered prominent by extension of the head, and the vessels are pushed back and escape on account of their elasticity. The lumen of the vessel may be opened, due to erosion of the wall by surrounding pus or as the result of softening produced by carcinomatous or sarcomatous degeneration.

The amount of the hemorrhage depends on the kind of injury, the position and extent of the wound, and whether the bleeding is primary or secondary. In incised wounds and stabs the primary hemorrhage will demand most attention. It is most marked when the vessel is completely severed, but may be considerable in cases of partial separation. If the direction of the wound is transverse or diagonal, the bleeding may be excessive, because in these cases the opening usually gaps. In any event, anæmia may cause death within a few minutes. With small wounds, especially longitudinal ones, the primary bleeding not infrequently ceases spontaneously, for the secondary weakness of the heart's action is followed by diminished blood-pressure, which is insufficient to drive the blood through the small tear in the vessel. In these cases the wound in the vessel is usually closed by a thrombus. A small external wound especially favors this condition because pressure of the intercellular hæmatoma on the injured vessel helps to stop the flow of blood. In this way complete recovery may take place, although there is always danger of secondary hemorrhage, formation of aneurism, and suppuration of the hæmatoma.

PLATE II.



Superficial Arteries of the Neck. (Spalteholz.)

Secondary hemorrhage may take place in the first few days after the injury—usually after the fifth day, sometimes after the eighth or tenth or even the fourteenth day—and may occur once or repeatedly. Bleeding of this sort may cause the death of an individual supposed to be out of danger. The cause of this hemorrhage is loosening of the thrombus within the vessel. This in turn takes place on account of the increasing blood-pressure after the initial shock. Traction on the vessel due to restlessness of the patient, and, finally, softening following suppurative processes, may have the same effect.

Secondary hemorrhage plays a major part in gunshot-wounds where the primary flow is often insignificant. Especially in cases in which an artery has been completely divided by the projectile there exists the possibility that the crushed ends may retract within the sheath and that the intima may become rolled up. The lumen is then occluded by a clot. Secondary hemorrhage occurs on the eighth or tenth day when the necrotic portion of the vessel-wall separates.

Diagnosis.—Since treatment depends on determining the extent and kind of injury to the vessel, it is important to make an accurate diagnosis. In practice this is often accompanied by great or even insurmountable difficulties. Two points should be settled: first, whether the bleeding is arterial or venous, and then, which vessel is injured. Although immediately after the injury it is easy to determine whether the hemorrhage is venous or arterial, it may be difficult or impossible to decide this when some time has intervened and primary hemorrhage has stopped. Owing to cardiac weakness the blood flows out slowly and continuously from the wound and has a dark color, so that its character is that of venous hemorrhage in spite of injury to an artery. The diagnosis in these cases must depend on the history, which frequently does not give the desired information, on the extent of the swelling produced by the intercellular hæmatoma, and the condition of the pulse in the terminal branches of the artery supposed to be injured. Under certain circumstances the presence of Wahl's symptom may be of importance. There is a rubbing or blowing murmur present at the seat of injury synchronous with the heart-beat, heard only when the vessel is partially severed and absent when it is completely divided. In some cases a diagnosis can be made only by inspecting the anatomical conditions after enlarging the wound. The difficulty in accurately locating the injury varies, and is dependent chiefly on the topography of the affected region. For this reason the difficulties in the upper and lower triangle of the neck may be greater than in the middle one. An important symptom is absence of the pulse in the peripheral branches. In injuries of the carotid absence of the temporal pulse, and with injury to the subclavian absence of the radial pulse will be found. It must, however, be taken into consideration that collateral circulation adjusts itself within a few hours; and that, on the other hand, there may be no pulse on account of marked anæmia or because the peripheral circulation has been disturbed by pressure of the intercellular hæmatoma.

Prognosis.—The prognosis varies in different cases, and is dependent on the size and importance of the artery affected, and on the extent of the injury as well as on the possibility of obtaining rapid aid. It is also greatly influenced by the treatment. Even after most complicated injuries recovery may be possible provided surgical interference is promptly extended. In a case recently reported by Thomas both carotids and jugular veins of one-half of the neck were ligated in an incised wound (suicidal attempt), and although at the same time the adjoining muscles and nerves (vagus, sympathetic, hypoglossus, brachial plexus) were completely or partially severed, complete recovery took place.

Treatment.—Injury to organs in the neck, especially to the vessels and nerves, is not necessarily fatal if it is possible to prevent secondary effects, the most important of which is hemorrhage. The fate of the wounded individual, therefore, is dependent upon the promptness with which aid can be given.

If a physician is present at the time the wound is inflicted, or arrives within a short time afterward, his object should be to stop the loss of blood as completely as possible. This is best done by pressure, and if possible by direct pressure upon the vessel-wall by a finger in the wound. Digital compression should be continued until the hemorrhage can be definitely stopped in some other way. If it is imperative to transport the patient immediately to a hospital for the purpose of operating, then the task of the physician becomes very difficult, and a firm pressure-bandage or compression upon the vessel-trunk near the wound must be substituted for digital pressure.

When a physician reaches the patient some time after infliction of an injury, primary hemorrhage has usually ceased owing to cardiac weakness. In such case the wound may be packed after it as well as the surroundings have been thoroughly disinfected. A pressure-bandage is next applied. In view of the possibility that only a small tear in the arterial wall may be present, which will heal spontaneously, it is justifiable to postpone interference. This condition is of rare occurrence, however, and as the patient is usually exposed to life-endangering complications (secondary hemorrhage, formation of aneurism, suppuration), it is best to open up the injured region freely, determine the extent of the wound, and stop the hemorrhage absolutely. In marked anæmia intravenous injection of salt solution should be given before the operation and no anæsthetic administered.

The customary method of stopping hemorrhage is double ligation *in loco*. This may, however, be difficult or even impossible on account of extensive infiltration of the tissues with blood, deep-seated position of the vessels, and difficult anatomical relations. At times it may be best to search for the main artery and compress this temporarily, so as to be able to locate and tie the injured vessel without interfering hemorrhage. It is advisable to make a large incision in the skin for the purpose of exposing thoroughly the field of operation. When complete occlusion of the injured vessel involves direct danger to life, or when it is desirable to preserve the vessel if possible, then suture of the arterial wall may be performed.

Detailed Description of Injuries of the Main Vessels in the Neck.

Subclavian Artery.—Injury to this vessel is uncommon, for it is covered by the collar-bone and the sternomastoid and occupies a very protected position. The chief injuries are stab- or gunshot-wounds where the instrument or the ball has penetrated above the clavicle or below in the infraclavicular fossa. Complications are frequently present on account of injury to the neighboring organs. In 13 cases reported by Rotter the vein was injured five times, the nerves twice, and the pleura three times. In cases of gunshot-wound the clavicle or first rib may be extensively splintered.

Prognosis.—The prognosis is unfavorable. Most of those injured in this way succumb at once. Of the 13 cases reported by Rotter, 6 lived where no secondary hemorrhage appeared after cessation of the primary bleeding; however, they developed aneurisms which caused death in 1 case and loss of function of the arm on that side in the other 5. Of the other 7 cases, secondary hemorrhage with fatal result took place in 6, and in only 1 case did complete recovery follow double ligation.

Treatment.—The treatment consists in double ligation of the vessel at the seat of injury. This is difficult, and at times possible only after resection of the clavicle. (See below.)

Vertebral Artery.—This artery may be injured anywhere in its course, but most frequently at the level of the atlas or between this and the occiput. The external wound therefore is usually below and behind the mastoid, beneath the lobe of the ear, or at the nape of the neck.

Diagnosis.—The diagnosis is especially difficult if the injury is near the origin of the artery below the carotid tubercle, because it is often impossible to differentiate between hemorrhage from the carotid artery on account of the proximity of this vessel. Valuable information may be obtained by pressing first below the sixth cervical vertebra and then above the same. If in the latter case the hemorrhage ceases, then the flow must be from the carotid; whereas, if it stops in the former case, it may come from the vertebral artery.

Prognosis.—The prognosis is unfavorable: first, because of the difficulty in exposing the seat of hemorrhage; secondly, because of the frequency of complicating injuries to the vertebræ and spinal cord; and, finally, on account of the danger of meningitis. Only 4 cases of recovery are reported out of 41 collected by Küster.

Treatment.—The indications are to ligate the artery *in loco.* This frequently cannot be done, and the vessel must be exposed before its entrance into the bony canal and tied. At times it may be possible to expose the seat of injury and tie the artery here after compressing the vessel temporarily before it enters the foramen of the sixth vertebra.

Carotid Artery.—The common carotid is the vessel most frequently the seat of injury. In suicidal attempts the artery is usually severed transversely at about the level of the thyroid cartilage. This is followed by hemorrhage which terminates fatally within a short time, especially if life-endangering complications of neighboring organs are present. The vessel alone may be injured in stab- and gunshot-wounds, as well as by operative interference, particularly during excision of adherent tumors. Finally, the wall may be eroded by pus or by malignant growths. In the latter case only partial solution of continuity is present, and it may be possible to stop the hemorrhage by pressure-bandages or the bleeding may cease spontaneously.

Injuries to the external or internal carotid are uncommon. They are usually produced by stab- or gunshot-wounds below the angle of the jaw, although the internal carotid may be opened from the pharynx. The diagnosis of the seat of injury and the application of a double ligature are difficult on account of the anatomy of this region, and at times it may be necessary to ligate the common carotid.

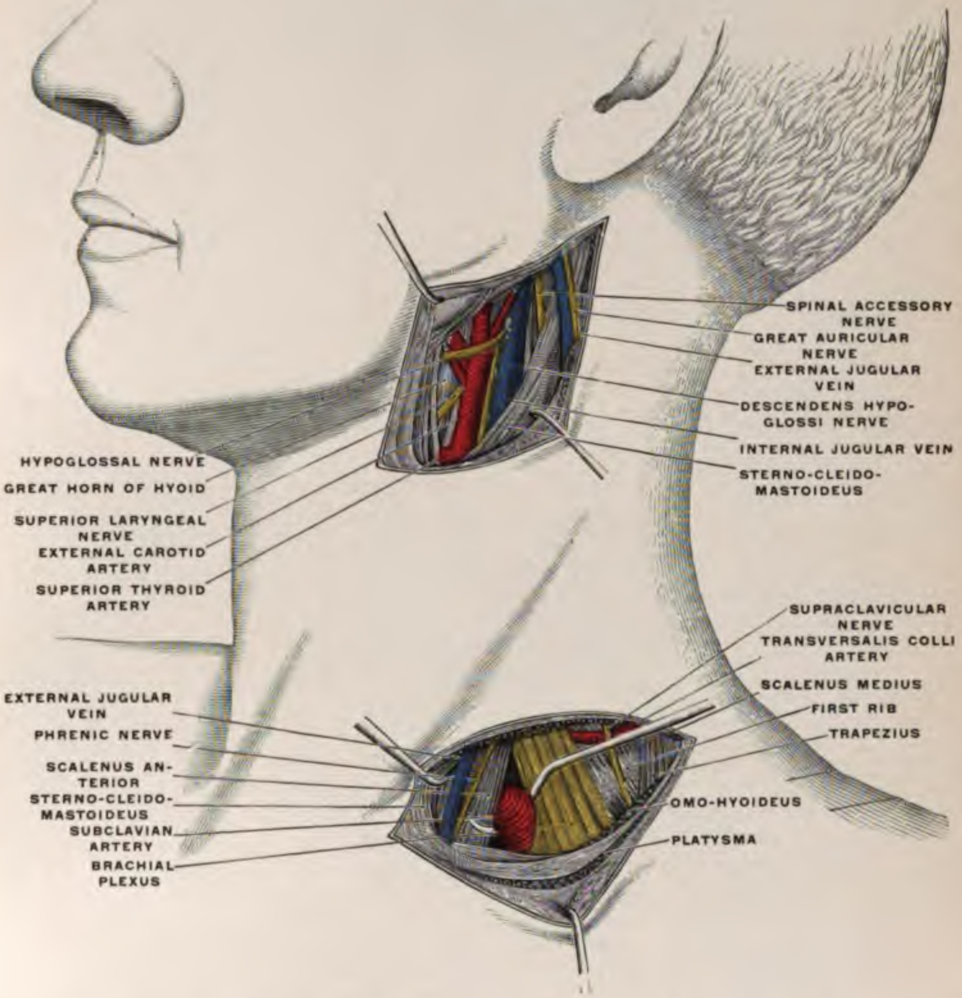
LIGATION OF ARTERIES IN THE NECK.

Ligation of the Common Carotid. (Fig. 11.)—**At the Level of the Cricoid Cartilage.** (Cooper.)—The skin incision is made along the inner margin of the sternomastoid from the level of the upper margin of the thyroid cartilage downward about 6 cm. The head is strongly extended. After separation of the platysma the sternomastoid is exposed and retracted outward, taking care to save the superficial veins. The depressors of the hyoid bone and the thyroid gland are then pulled toward the median line, and the omohyoid is depressed. The vessel-sheath is exposed in this way and carefully opened after dissecting off the descendens cervicalis as it runs downward on the artery. In the common sheath the artery is to the inside, the internal jugular vein to the outside and superficial; the vagus lies between and behind. The sympathetic nerve lies behind the common sheath. The artery is separated carefully with a curved blunt dissector or director, always bearing in mind the surrounding structures. The ligature is applied from the outer side.

Kocher exposes the artery by a transverse incision at the level of the cricoid cartilage across the anterior margin of the sternomastoid. After exposing the muscle and retracting it to the outer side, the omohyoid will be seen running upward and inward. The artery will be found in the angle formed by these muscles.

Between the Heads of the Sternomastoid. (Zang.)—The interval between the sternal and clavicular portion of the sternomastoid is exposed by an incision about 5 or 6 cm. long, reaching to the clavicle. The common jugular vein thus exposed is retracted outward with the clavicular portion. The sternal portion is drawn to the inside with the sternohyoid and sternothyroid muscles. The artery may now be separated from the vagus and ligated.

PLATE III.

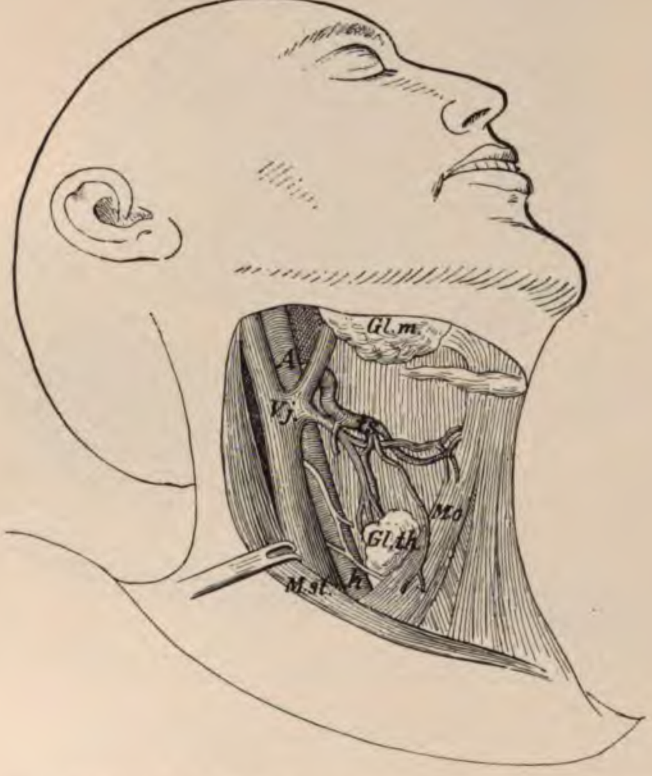

SPINAL ACCESSORY NERVE
GREAT AURICULAR NERVE
EXTERNAL JUGULAR VEIN
DESCENDENS HYPOGLOSSI NERVE
INTERNAL JUGULAR VEIN
STERNO-CLEIDO-MASTOIDEUS
HYPOGLOSSAL NERVE
GREAT HORN OF HYOID
SUPERIOR LARYNGEAL NERVE
EXTERNAL CAROTID ARTERY
SUPERIOR THYROID ARTERY
SUPRACLAVICULAR NERVE
TRANSVERSALIS COLLI ARTERY
SCALENUS MEDIUS
FIRST RIB
TRAPEZIUS
EXTERNAL JUGULAR VEIN
PHRENIC NERVE
SCALENUS ANTERIOR
STERNO-CLEIDO-MASTOIDEUS
SUBCLAVIAN ARTERY
BRACHIAL PLEXUS
OMO-HYOIDEUS
PLATYSMA

Surgical Relations of the External Carotid, Lingual, Facial, Occipital, Subclavian and Transverse Cervical Arteries. (Kocher.)

König recommends an incision at the inner side of the sternomastoid, and division of the lower fibres of this muscle if necessary, so as to expose the artery more directly.

The indications for ligation of the carotid have undergone considerable limitation since it has been demonstrated that the danger of this procedure has not been diminished in spite of the advances in the treatment of wounds and in operative technic. The danger, even without thrombosis at the seat of ligation, consists in shutting off the supply of arterial blood from a vital organ. The fate of an individual depends upon the rapidity with which collateral circulation is established. Conditions necessary for a favorable result are, first, the existence of abundant anastomoses of the peripheral branches; and, secondly, the capacity of these vessels to distend sufficiently.

FIG. 11.



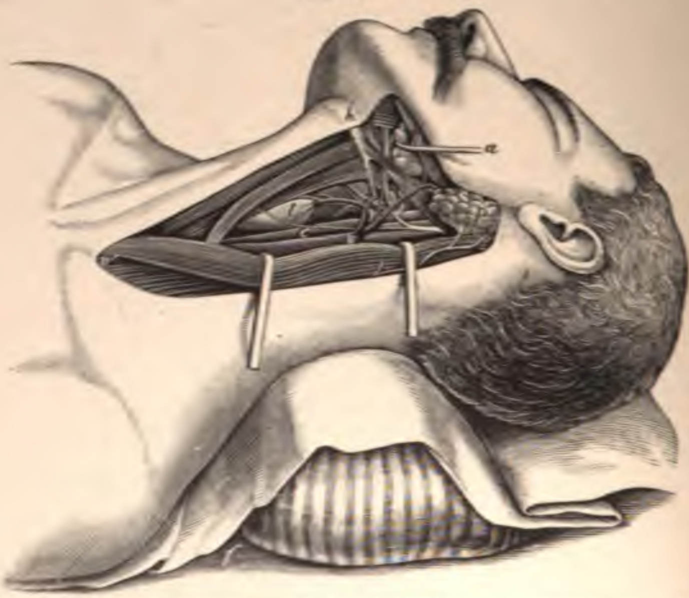
A, carotid artery; *V. j.*, jugular vein; *M. st.*, sternomastoid; *M. o.*, omohyoid; *t. s.*, superior thyroid artery; *h*, hypoglossal nerve; *Gl. th.*, thyroid gland; *Gl. m.*, submaxillary gland.

1. After exclusion of one side the section of brain supplied by the common carotid may receive its blood from the carotid of the other

side through the communicans anterior, through the vertebral artery, through the communicans posterior; and, finally, blood may reach the area of distribution of the ligated vessel through anastomoses between the terminal branches of the external carotids. A normal development of the circle of Winslow is of cardinal importance for collateral circulation, and lack of development in the communicating arteries, which is not uncommon, may result in difficulty.

2. The capacity of vessels to distend rapidly and perform vicarious function is dependent on their elasticity. Any morbid change which diminishes the elasticity, especially arterial sclerosis, influences the power of dilatation to a greater or less degree. This hypothesis is supported by the fact that the greatest number of recoveries after ligation of the carotid take place in youthful individuals. The percentage of mortality increases with increasing age; and, furthermore, ligation performed in cases of neuralgia, in which the vessels, generally speaking, are normal, shows the lowest death-rate (3 per cent.). Sufficient blood-pressure and adequate supply of blood are, of course, essential for the development of collateral circulation. Where these conditions are absent—as, for instance, following great loss of blood—the danger of ligation is considerably increased. The death-rate of ligation is correspondingly higher—54 per cent., according to the statistics of Pilz.

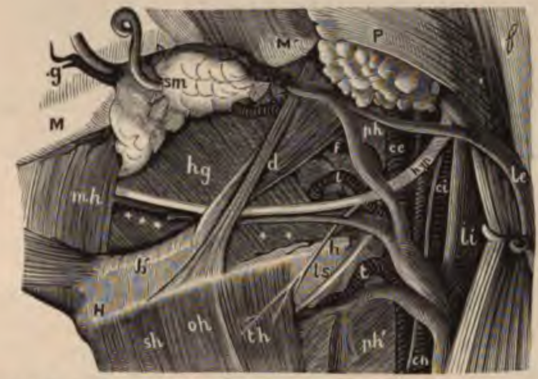
Fig. 12.



Anterior triangle of neck: *a*, submaxillary bone; *b*, hyoid bone; *c*, carotid artery; *v*, jugular vein; *P*, parotid gland; *t*, thyroid gland. (Farabeuf.)

As with other large vessels of the body, so with the common carotid, the disagreeable results of sudden occlusion may be lessened and the development of collateral circulation favored by previous compression. This fact is also borne out by the experience that the results of ligation in the treatment of aneurism are relatively favorable (31 per cent. mortality, Pilz) where digital compression has been previously applied. The same holds true in excision of tumors (26 per cent.) where the vessel has been subjected to considerable pressure for a long time.

FIG. 13.

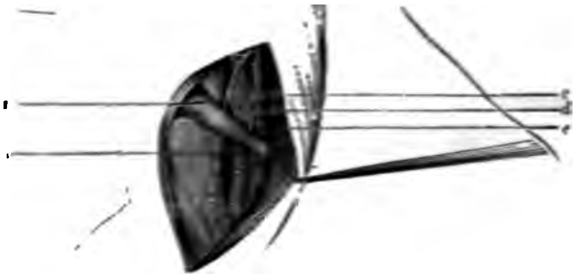


Submaxillary region : *M*, ramus of jaw ; *M'*, masseter ; *sm*, submaxillary gland ; *P*, platysma ; *mh*, mylohyoid ; *hg*, hyoglossus ; *d'*, tendon of digastric ; *d*, posterior belly of digastric ; *H*, body of hyoid bone ; *h*, great cornu of hyoid ; *sh*, sternohyoid ; *oh*, omohyoid ; *th*, thyrohyoid (ought to be on deeper plane) ; *ls*, superior laryngeal nerve ; *t*, superior thyroid artery ; *l*, lingual artery ; *f*, facial artery ; *cc*, external carotid ; *ci*, internal carotid ; *je*, external jugular ; *ji*, internal jugular ; *hyp*, hypoglossal nerve ; *ph*, *ph'*, constrictor of pharynx. (Farabeuf.)

In each individual case the conditions governing collateral circulation can never be absolutely known before operation, and the prognosis must always be guarded. Ligation should be done only after careful consideration of all related factors and in the presence of a positive indication. The danger is expressed in the following statistics : Pilz, in 1867, collected 600 cases of ligation of the carotid belonging to the pre-antiseptic era : 319 (53 per cent.) of these recovered, 259 (43 per cent.) resulted fatally, and in 22 the result was not given. If 29 cases are deducted in which death was due to other causes, the mortality remains 38.3 per cent. In 1880 Pilz collected 914 cases, with a death-rate of 39 (8 per cent.). Lefort placed the death-rate at 43 per cent., based on 435 observations in France. Finally, 70 cases belonging to the aseptic era were collected by Zimmermann from 1885 to 1891 ; 31 per cent. of these died as the result of ligation. In about one-third of all the cases therefore an unfavorable result is to be expected.

This large death-rate is explained by disturbances of nutrition in the cerebral hemispheres, and autopsies on the human being as well as experiments on animals (especially by Van Nees) show that in the regions of the brain deprived of their circulation processes of softening take place. The latter are of two types : white ischæmic necrosis and hemorrhage yellow or red softening. White softening presupposes total anæmia of the region of the brain effected by thrombosis or by embolic occlusion of the peripheral branches. Following this there develops progressive disintegration of the tissue, which is changed to a granular mass. Red or yellow softening, on the other hand, occurs when anæmia is associated with venous congestion, capillary hemorrhages, and transudation into the tissues. This form is more frequent, and is not necessarily associated with complete ischæmia.

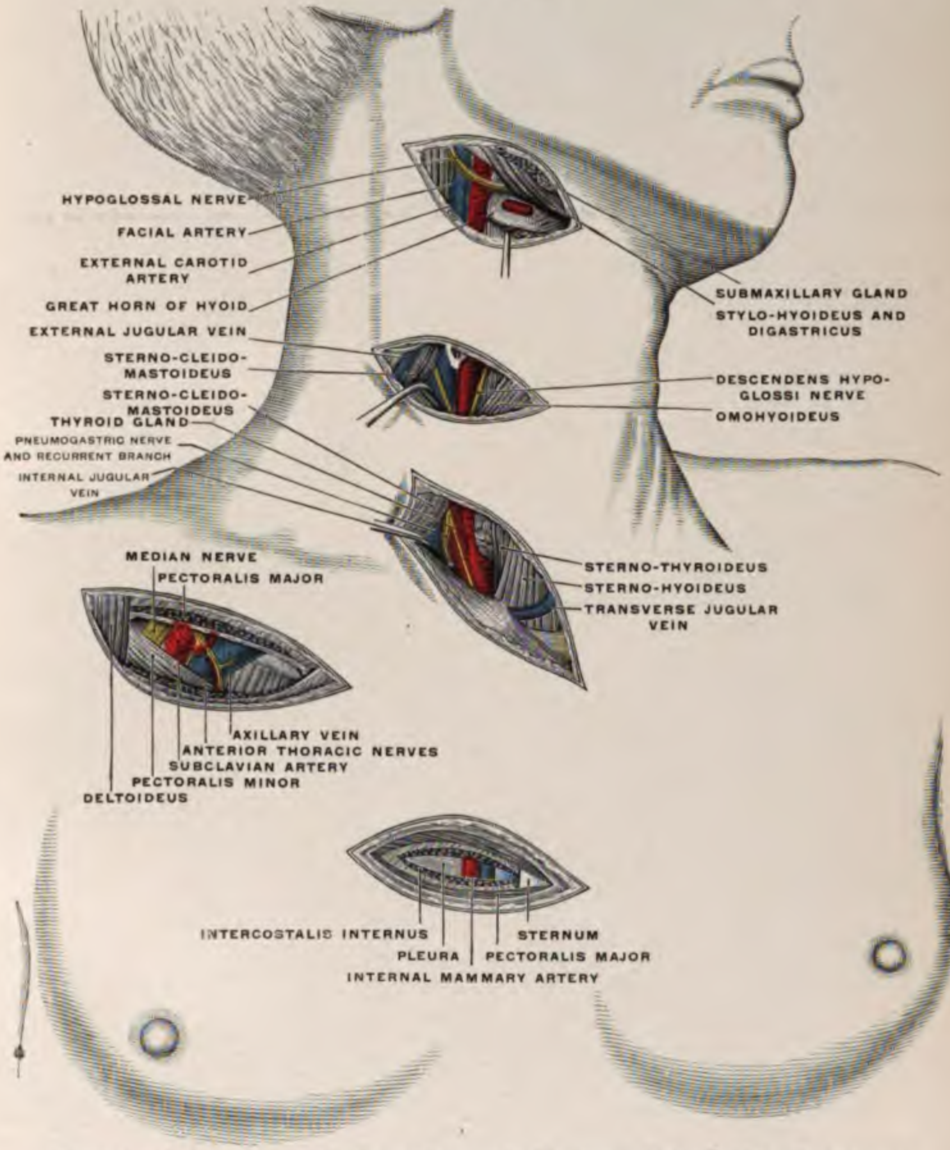
FIG. 14.



Common carotid below omohyoid. a, anterior belly of omohyoid; b, common carotid; c, jugular vein; d, pneumogastric; e, sterno-mastoid.

Pilz explains the brain-changes in the following way: Owing to the sudden diminution in the quantity of blood in the small arteries cerebral anæmia takes place because the *vis a tergo* which propels the blood forward is absent. If this condition lasts any length of time without collateral circulation being established, permanent changes of structure in the brain occur. According to Zimmermann, various factors are to be taken into consideration in cases of softening. Following ligation there may be progressive thrombosis extending to the small arteries in the brain and producing complete absence of blood in these regions, or there may be embolic occlusion, or a thrombus reaching up to the nearest branch of the artery ligated is torn off by a blood-wave and carried to the small arteries in the brain. Finally, softening of the brain may be produced by insufficiency of the collateral circulation even when there is no thrombosis at the seat of ligation, as is the case as a rule in aseptic wounds. Pilz's statistics show that disturbances of brain functions take place in about 32 per cent. of [illegible] the death-rate in cases showing these symptoms is [illegible]. [illegible] enlarged Pilz's statistics in 1885, found [illegible] symptoms were present 17 times in 73 operations, therefore [illegible]. Zimmermann's statistics show brain symptoms [illegible] and fatal softening of the brain in 11 per [illegible]. The [illegible] symptoms after ligation of the carotid when col[illegible] are analogous to those produced by experi[illegible] this in man. Kussmaul and Tenner.) [illegible] headache, dizziness, weakness in the legs, [illegible] fainting, nausea, and convulsions. These symptoms may gradually disappear with subsequent development of

PLATE IV.


HYPOGLOSSAL NERVE
FACIAL ARTERY
EXTERNAL CAROTID ARTERY
GREAT HORN OF HYOID
EXTERNAL JUGULAR VEIN
STERNO-CLEIDO-MASTOIDEUS
STERNO-CLEIDO-MASTOIDEUS
THYROID GLAND
PNEUMOGASTRIC NERVE AND RECURRENT BRANCH
INTERNAL JUGULAR VEIN
SUBMAXILLARY GLAND
STYLO-HYOIDEUS AND DIGASTRICUS
DESCENDENS HYPOGLOSSI NERVE
OMOHYOIDEUS
MEDIAN NERVE
PECTORALIS MAJOR
STERNO-THYROIDEUS
STERNO-HYOIDEUS
TRANSVERSE JUGULAR VEIN
AXILLARY VEIN
ANTERIOR THORACIC NERVES
SUBCLAVIAN ARTERY
PECTORALIS MINOR
DELTOIDEUS
INTERCOSTALIS INTERNUS
STERNUM
PLEURA
PECTORALIS MAJOR
INTERNAL MAMMARY ARTERY

Surgical relations of the Lingual, External Carotid, Common Carotid, Brachiocephalic, Subclavian and Internal Mammary Arteries. (Kocher.)

collateral circulation, because the nutrition of the brain becomes restored. If, however, structural changes take place, the disturbances manifest themselves as hemiplegia, which according to Pilz, occurs in more than 8 per cent. of the operated cases. Even these paralyses may improve in time. In individual cases the disturbances of nutrition progress until fatal softening of the brain supervenes. Ligation of both carotids is, of course, more dangerous than unilateral ligation, because the brain is then dependent for its blood-supply upon the vertebral arteries alone. But even in cases of double ligation favorable results have been reported, and the chance of recovery is greater the longer the interval between the respective ligations.

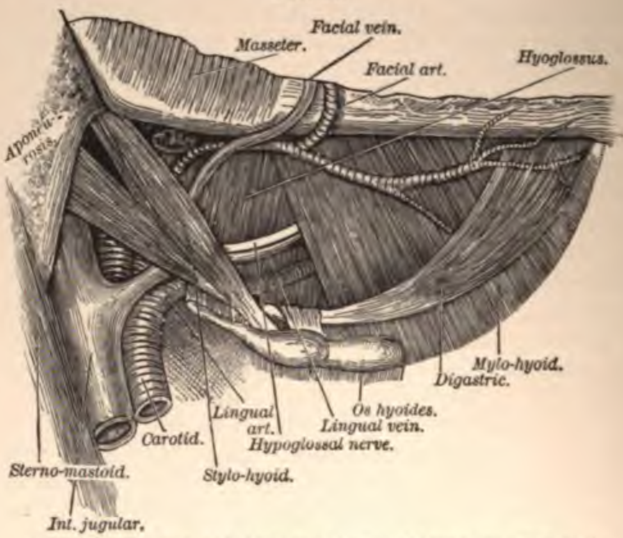
Ligation of the carotid is indicated in hemorrhage following injuries or erosion of the vessels; in cases in which a malignant growth is so adherent to the artery that it cannot be separated and removal is possible only after resection of a portion of the vessel; in cases of aneurism. All other indications formerly considered justifiable are to be condemned —therefore ligation for the purpose of relieving severe facial neuralgia, for the purpose of bettering epileptic conditions, to avoid the results of apoplexy, to effect removal of inoperable tumors, and finally to avoid hemorrhage in operations on the face.

Ligation of the External Carotid.—Ligation of the external carotid is not dangerous, as disturbances of the brain in aseptic cases are not to be feared (absence of extensive thrombosis). Death following thrombosis was observed in only 2 cases out of 130 collected by Lipps from current literature. These thrombi extended into the internal carotid and gave rise to embolism in the brain (1.54 per cent. mortality). In 30 other cases death was due to sloughing, sepsis, pneumonia, secondary hemorrhages, and simultaneous and accidental ligation of the common carotid. The 12 cases of double ligation all resulted favorably. No disastrous symptoms have as yet been reported following ligation.

The indications for ligation are as follows: 1. Injuries of the neck with laceration of the artery. 2. Inseparable adhesions between tumors and the vessel (lymphosarcoma, carcinoma). 3. For depriving inoperable vascular growths of the face and head of their blood-supply. 4. For the purpose of complete hæmostasis in excision of tumors of the face; ligation of the carotid has been especially recommended by Kocher as a preliminary in resection of the upper jaw. 5. In rare cases ligation may serve as a palliative measure in inoperable carcinoma of the face, so as temporarily to check the growth. The idea that a cure was produced by ligation has been shown to be incorrect, so this procedure is limited to special cases. Ligation is useless in severe forms of facial neuralgia. If any indication is present to produce complete hæmostasis in the region of the external carotid, it is advisable to tie the thyroid artery as well as the main trunk, because hemorrhage may result from the anastomosis between the thyroids.

Technic.—The line of incision is along the inner border of the sternomastoid from the angle of the jaw to the level of the thyroid cartilage. In the lower angle of the wound the facial vein and thyroidal veins are retracted downward, the digastric and hypoglossal nerves upward, while the internal carotid artery and the internal jugular vein are pulled to the outer side. The ligature is passed from the outer side around the exposed artery. Kocher advises ligation through his incision for the upper triangle of the neck, which is from the anterior edge of the apex of the mastoid process one finger's breadth behind and below the angle of the jaw to the middle of the hyoid bone. The point of ligation with this incision is one finger's breadth vertically below the angle of the jaw.

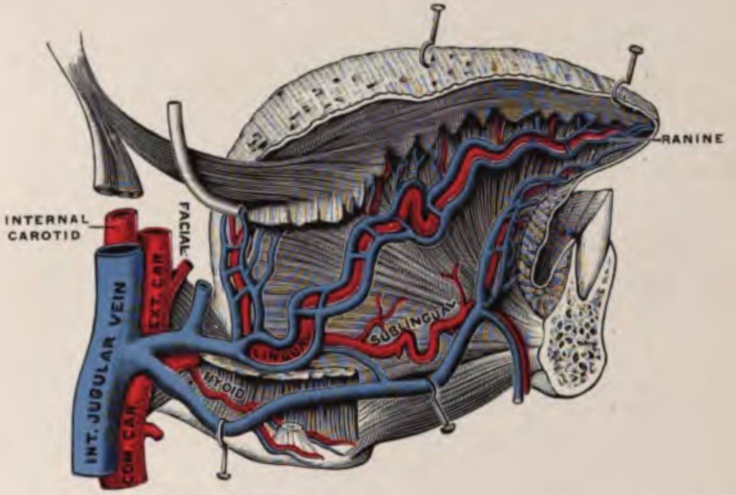
FIG. 15.



Anatomical relations of the lingual and facial arteries. (Tillaux.)

Ligation of the Lingual Artery.—The chief indication for ligation is to produce as complete hæmostasis as possible in excision of tumors of the tongue, especially in cases of carcinoma. In these cases ligation is a preliminary step to the operation proper. The technic is easy because the submaxillary gland and surrounding lymph-glands are without the field of operation. In inoperable cancer of the tongue ligation of the lingual has been followed by temporary improvement, such as diminution of pain and lessened disturbance of function. There is less bleeding, and the growth tends to remain stationary. A cure, of course, is not to be expected. Tuffier reports 5 cases in which, following ligation of both lingual arteries or of both external carotid arteries, improvement took place in the local conditions, which lasted, however, but a few weeks. Considering the hopelessness of any other therapeutic measure in inoperable cancers, especially if they give rise to frequent hemorrhage, ligation of the lingual on both sides will have to be considered. Hemorrhage from wounds of the tongue is rarely an indication for ligation of this artery, for the

PLATE V.


INTERNAL CAROTID
FACIAL
RANINE
INT. JUGULAR VEIN
EXT. CAR.
COM. CAR.
LINGUAL
SUBLINGUAL
HYOID

Arteries and Veins of the Tongue, Viewed from the Right Side. (Testut.)

safest procedure is to ligate *in loco.* This artery, being the second branch of the external carotid, runs inward almost horizontally on the mylohyoid beneath the digastric and stylohyoid muscles, underneath the posterior margin of the hyoglossus, then upward and inward into the substance of the tongue. The vein and the hypoglossal nerve are outside of the hyoglossus parallel to the artery. There are, however, exceptions to this rule. Funke describes an anomaly, previously observed by Zuckerkandl, which must be borne in mind in ligating this vessel. In both cases the artery was situated on the hyoglossus between the hypoglossal nerve and the cornu of the hyoid bone, and turned inward at the anterior margin of the hyoglossus and posterior margin of the genioglossus. A ligature may be applied either before the artery passes under the posterior belly of the digastric or in the trigonum lingualæ after passing the digastric tendon.

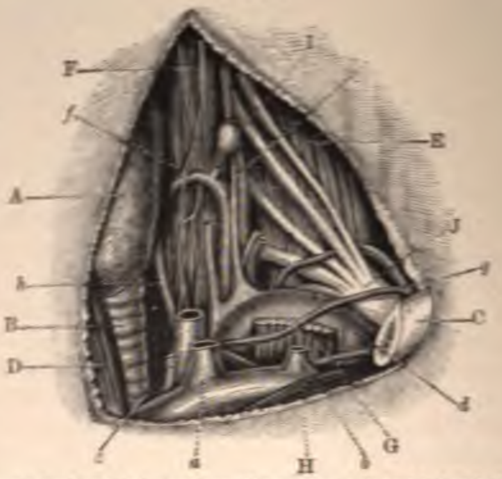
Technic.—1. A pillow is placed under the neck and the head extended and turned toward the opposite side so as to expose the field of operation as much as possible. Especially with short and fat necks a suitable position of the patient is of importance in facilitating the operation. The skin incision is made immediately above the large cornu of the hyoid bone from the anterior margin of the sternomastoid to about the middle line of the neck. The platysma is divided, the facial vein retracted outward, and the posterior belly of the digastric exposed. After opening the capsule the submaxillary gland is pushed upward if necessary. The hypoglossal nerve with the lingual vein appears behind the digastric, and must be pulled upward with a blunt hook. The fibres of the hyoglossus are then carefully separated just above the hyoid bone and the artery exposed in this place. This part of the operation may be made easier by dragging the hyoid bone outward with a sharp hook, as advocated by Thiersch. This operation has been recommended chiefly by Malgaigne and Roser.

2. For the purpose of tying the vessel above the tendon of the digastric as recommended by Guérin, an incision is made in the skin about 5 mm. above the cornu of the hyoid bone and parallel to this. A triangle is thus exposed, bounded by the posterior belly of the digastric, the external free margin of the mylohyoid on each side, and by the hypoglossal nerve above. The apex is at the seat of junction of the bellies of the digastric and the hyoid bone. The artery will be found beneath the hyoglossus, which forms the floor of this small triangle. The vessel is exposed by separating the muscle-fibres, and as in the preceding method, the submaxillary gland is displaced upward so as to give a better view of the field of operation.

With proper asepsis, ligation of the lingual artery is devoid of danger. The infrequent cases of death reported in early statistics were due to infection of the wound.

Ligation of the Vertebral Artery.—Ligation of this vessel is difficult on account of its deep position, because of the possibility of confounding with the inferior thyroid artery or the ascending cervical, and because of the proximity of important nerves and vessels. It is usually ligated in the first 4 cm. of its course. Several methods have been recommended for the purpose of exposing the artery.

FIG. 16.



Anatomy of the vertebral and inferior thyroid arteries: *A*, thyroid gland; *B*, trachea; *C*, clavicle; *D*, sternothyroid; *E*, scalenus medius; *F*, longus colli, with sympathetic nerve upon it; *G*, scalenus anticus (cut); *H*, subclavius; *I*, transverse process of the sixth cervical vertebra; *J*, brachial plexus; *a*, left innominate vein, receiving internal jugular; *b*, jugular vein, entering subclavian vein; *c*, common carotid artery, with vagus nerve to its inner side; *d*, subclavian artery crossed by nerve to subclavius; *e*, vertebral artery and vein; *f*, inferior thyroid artery. (From Treves.)

Chassaigne's Method (1861).—An incision is made almost down to the clavicle along the posterior margin of the sternomastoid. The external jugular is drawn to one side or tied between two ligatures. The muscle with the large vessels and nerves is retracted to the inner side. The carotid tubercle is next sought for. The deep fascia is divided, care being taken to avoid the ascending cervical artery, and the space between the scalenus anticus and the longus colli is opened by blunt dissection. After dividing the aponeurosis between both muscles, the artery with its vein may be seen about 2 cm. below and inside the tubercle.

Method of Prays and Kocher.—An incision is made along the inner margin of the sternomastoid down to the suprasternal notch, the platysma and fascia divided, the sternomastoid and large vessels retracted outward, and the sternohyoid pulled to the inner side. The prevertebral fascia is divided above the inferior thyroid artery, and the vertebral artery exposed. It is partly covered by fibres of the longus colli, has a vertical course, and disappears at the lower margin of the sixth cervical vertebra.

Mikulicz's Method.—In cases in which it may be difficult to find the vessel on account of pathological conditions Mikulicz recommends division of the clavicular portion of the sternomastoid 3 cm. above the insertion, so as to expose freely the artery at its origin. The skin incision is made along the posterior margin of the sternomastoid from about the level of the thyroid downward. The severed muscle is reunited with catgut after the ligature to the vessel has been applied.

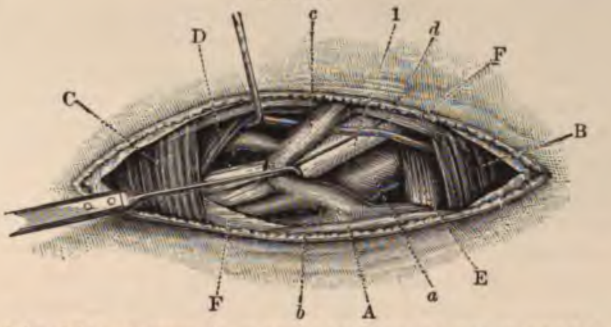
Helferich's Method.—Helferich advised attacking the artery in the transverse process of the sixth cervical vertebra so as to avoid confounding with neighboring vessels. The skin incision is made along the anterior or posterior margin of the sternomastoid and the muscle retracted to the outer or inner side. The carotid tubercle is sought for in the upper end of the wound. The periosteum is stripped up and the outer portion of the transverse process nipped off with bone-forceps, thereby exposing the artery and vein in the canal. The large vessels and nerves are not seen; the phrenic nerve is situated to the outer side and the inferior thyroid artery is below.

As a rule no unfavorable results follow ligation of the vertebral artery, for collateral circulation is readily established through the circle of Willis, and the carotids are obliged to supply the brain with a greater amount of blood. In a case reported by Baracz, in which both vertebral arteries were tied fourteen days apart for epilepsy, right-sided hemiplegia developed; this, however, disappeared within two months. In 5 other cases of unilateral or bilateral ligation Baracz noted no disturbances; and Alexander, who has ligated the artery on one or both sides in 36 cases for epilepsy, never noticed unfavorable brain symptoms.

Contraction of the pupil on the same side has frequently followed ligation of the vertebral artery. This action of the pupil is explained by some injury to the fibres of the sympathetic, dilating the pupil, part of which do not run in the lateral trunk, but with the vertebral artery.

Ligation of the Subclavian Artery in the Supraclavicular Fossa.—The origin of this artery is behind the manubrium sterni. It

FIG. 17.



Ligation of the right subclavian (third part): *A*, clavicle; *B*, sternomastoid; *C*, trapezius; *D*, omohyoid; *E*, anterior scalena; *F*, cervical fascia; *a*, subclavian artery: *b*, subclavian vein; *c*, external jugular vein; *d*, transverse cervical artery; 1, brachial plexus. (From Treves.)

then crosses the pleura of the apex of the lung, passes over the first rib, between the scalenus anticus and medius, and reaches the external surface of the thorax below the middle portion of the clavicle. As the vessel is very inaccessible to the median side of the scaleni muscles or between them, the part between the scalenus and the clavicle is usually considered the seat of election for ligation.

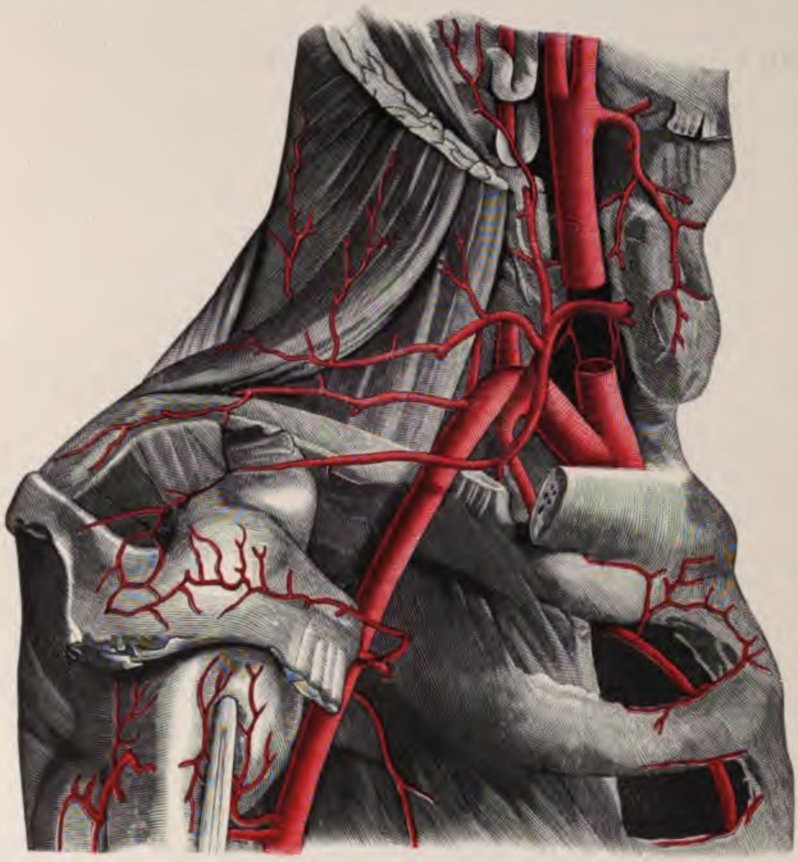
Technic.—An incision is made parallel to the collar-bone and a finger'-breadth above this, from the posterior margin of the sternomastoid to the trapezius. The platysma, fascia, and supraclavicular nerves are divided; the external jugular vein drawn aside or divided between double ligatures, and the omohyoid retracted upward and outward. The fat containing the glands situated in the lower triangle of the neck thus exposed is excised if necessary or pulled to one side, and the deep fascia covering the brachial plexus is divided. By following these nerves one comes to the tubercle of the first rib, the point of insertion of the scalenus anticus. The artery covered by the nerves passes behind this muscle, and should be ligated by passing the carrier from the outer side. The subclavian vein is below and in front of the tendon of the scalenus and immediately behind the collar-bone.

The space in which ligation must be performed is rather small, and the operation is often difficult, especially when the relations have been disturbed or obscured by hemorrhage into the tissues in stab- or gunshot-wounds. In such cases it is advisable to enlarge the field of operation by a vertical incision and divide the clavicle temporarily.

Ligation of the Arteria Innominata.—Ligation of this vessel is indicated only in very rare cases; most frequently after injury during operations upon tumors of the sternum or of the anterior mediastinum. In cases of stab- or gunshot-wound death usually follows so quickly that the surgeon hardly ever has an opportunity to stop the hemorrhage. In cases of aneurism of the terminal portion of the innominate the proximal portion very frequently cannot be reached for the purpose of ligation on account of the aneurismal sac. Ligation of this vessel in aneurism of the subclavian or carotid is counterindicated on account of the disturbances of the circulation produced. In a single celebrated case of injury to the right subclavian recovery took place after ligation of the innominate and simultaneous ligation of the common carotid. The vertebral artery, too, had been tied on account of secondary hemorrhage. The patient was in good condition ten years afterward. (Smith.)

Technic.—Mott in 1818 performed this operation for the first time, and recommended the following method, which even at the present day is the one chiefly used. After extending the head and turning it to the left, a horizontal incision is made above the margin of the collar-bone extending from about the middle of the clavicle to the jugulum. A second incision is carried upward from the inner end of the first along the anterior margin of the sternomastoid. The sternal end of the sternomastoid is now divided and retracted with the triangular flap to the outer side. The depressors of the hyoid bone as well as the cervical fascia are divided close to the sternum, and the large vessels thereby exposed. The internal jugular vein and the vagus are separated from the carotid by blunt dissection and retracted to the outer side, thus exposing the subclavian artery. By following this beneath the ster-

PLATE VI.



Right Subclavian Artery. (Spalteholz.)

num, being careful to avoid injury to the phrenic nerve and recurrent laryngeal, the innominate will be reached, around which an aneurism-needle is passed. One should avoid injuring the pleura.

Mott's incision has been modified by Gräfe, Pirogoff, and v. Langenbeck. Gräfe's diagonal cut runs from about the middle of the anterior margin of the right sternomastoid to the anterior surface to the manubrium sterni. Pirogoff made his incision vertical in the middle line and dissected downward between the sternohyoid and sternothyroid muscles. v. Langenbeck made a half-moon-shaped incision from the anterior margin of the sternomastoid, the convexity over the manubrium sterni, and between the sternohyoid muscles.

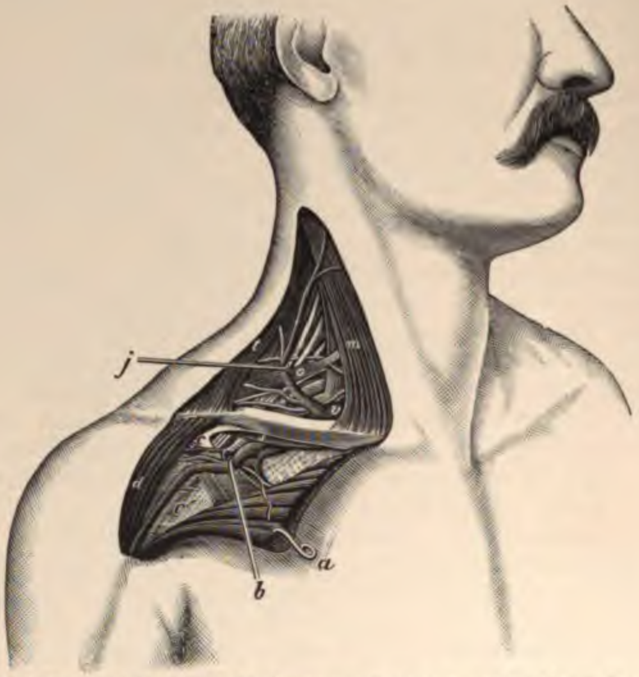
INJURIES OF VEINS IN THE NECK.

The disastrous results following injuries of veins in pre-antiseptic times, are not met with in the modern treatment of wounds, or only infrequently. But even to-day wounds of veins in the neck are life-endangering accidents owing to hemorrhage and the possibility of air entering the vessel. In former times the fatal complications following infection were phlebitis, thrombosis, and pyæmia.

The movements of the chest have considerable influence on the hemorrhage because the venous circulation is directly affected by breathing. During inspiration the flow of blood into the right auricle is much facilitated, so that bleeding from a small vein may sometimes cease during this period. On the other hand, if respiration is interfered with, the flow of venous blood is retarded, the blood backs up, and any hemorrhage is increased. This influence of breathing on the circulation and on hemorrhage from veins may be observed in tracheotomy for stenosis of the larynx.

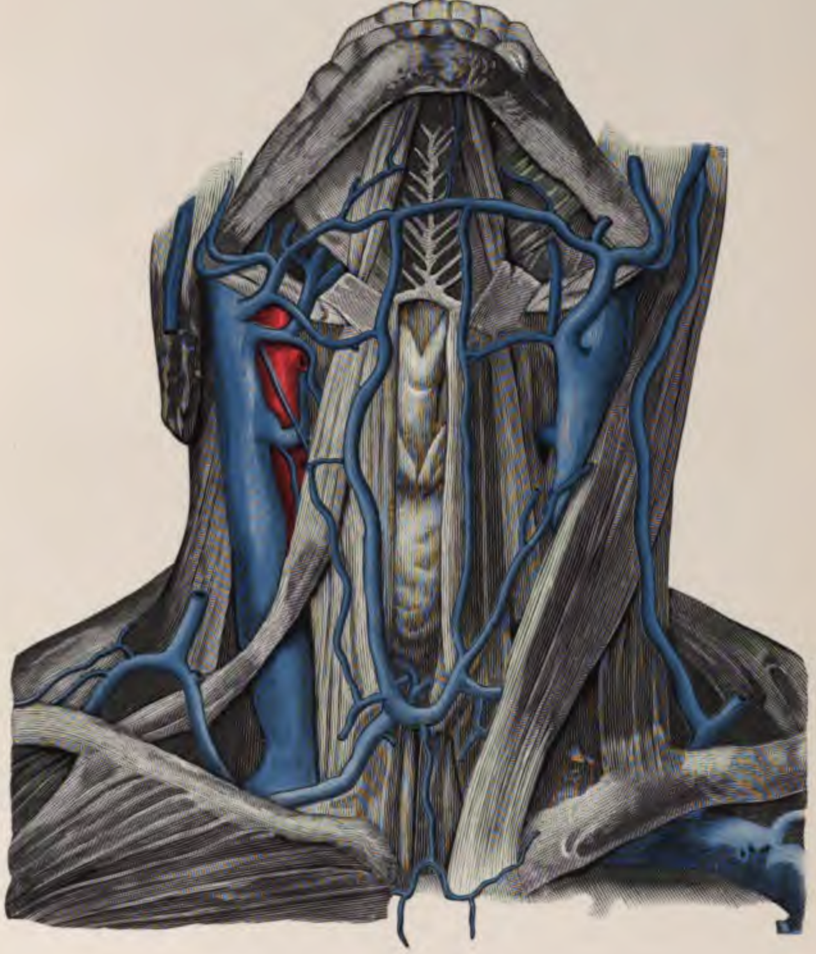
Owing to the negative pressure within the chest the flow of blood is quite rapid even in small veins. If a vein in this region be completely severed, the loss of blood may be so great and sudden that death results within a few moments. The veins of the neck have no valves and are therefore directly connected with the sinuses of the dura mater. Cerebral anæmia follows quickly in these cases. Injuries of the larger veins are still more dangerous than those of arteries. Fischer found that of 85 cases of injury of the internal jugular, 20 died when the aid of a surgeon could not be obtained. When the large veins are completely divided, instantaneous compression is the only measure that can prevent bleeding to death, and only in small lateral tears of the venous wall is it possible for the hemorrhage to stop spontaneously. The blood flows either outward directly or is poured into some cavity that has been opened at the same time, or into the tissues themselves (interstitial hæmatoma), according to the nature of the injury, the size and position of the wound, etc. Air has been observed to enter vessels after injuries of the veins of the neck, especially those at the root of the neck. The conditions that favor this are the motion of the chest during inspiration and the gaping of the vein after its division. The veins of the neck are held wide open and prevented from collapsing owing to their connection with the fascia. The external jugular vein is held open in this way where it perforates the cervical fascia at the posterior margin of the sternomastoid above the clavicle just before emptying into the subclavian vein or internal jugular. The subclavian vein is intimately united with the fascia of the scalenus and the cervical fascia inserted into the clavicle, so that this vein follows the excursions of the collar-bone and is opened widely when the arm is raised. The internal jugular vein finally is closely united in front with the cervical fascia and behind with the prevertebral fascia. Besides these normal adhesions, the veins may be closely united to the surroundings (tumors, inflammation), or the walls may be thickened, all of which would render it more difficult for the veins to collapse, and thus favor the entrance of air. In the majority of cases the entrance of air is announced by an intermittent hissing or gurgling sound. At the same time, or a few minutes afterward, symptoms referable to the heart and breathing appear. The patient turns pale, has an anxious expression, or screams; the breathing becomes more difficult; the pulse weak, frequent, irregular; the pupils are distended and do not react; consciousness is lost, convulsions and death closing

FIG. 18.



Supraclavicular and infraclavicular fossæ: *t*, trapezius; *o*, omohyoid; *m*, sternomastoid; *v*, subclavian vein; *d*, deltoid; *s*, subclavian muscle; *c*, coracoid process; *c′*, fascia; *a*, retracted pectoralis major; *b*, cephalic vein; *j*, external jugular vein. (Farabeuf.)

PLATE VII.



Veins of the Neck. (Spalteholz.)

the scene. This result is fortunately not the rule. The disturbances subside in a portion of the cases, and complete recovery may take place even when the symptoms have been severe. Of 64 cases collected in 1864, 24 died instantly or within a short time after the entrance of air, 27 recovered after more or less alarming symptoms, and in 9 cases no influence on the general condition was observed notwithstanding the hissing noise which was distinctly heard. It is doubtful whether Green's statistics contain cases that were accurately observed, for since the publication of these figures the number of cases reported has been small. Only 6 cases have since been reported, 1 of which resulted fatally. This accident, formerly so dreaded, seems to have become less frequent in late years, which may be partly due to improvement in technic in stopping hemorrhage and partly to operative conditions (complete anæsthesia). Even in Green's statistics are several cases in which fatal symptoms did not appear until after three, seven, or fifteen hours.

Animal experiments have been made in great number to ascertain why aspirated air leads to such disastrous results, and also to determine the conditions under which this takes place. The conclusions arrived at are not uniform.

Pirogoff, as well as Laborde and Muron, were able to inject slowly large quantities of air into the external jugular vein with impunity, and death took place only when 100–200 grammes were injected rapidly. Uterhart came to the conclusion that large quantities of air (300 grammes) could be injected without damage into veins situated at some distance from the heart. Fischer, on the contrary, found that when a broad cut was made at the base of the neck through the internal jugular vein of rabbits death followed in the majority of cases with signs of marked dyspnœa. A distinct hissing sound was heard. He concluded that even when a small quantity of air is forced into any vein—rapidly or slowly—death may follow. Chauveau was able to introduce large quantities of air into horses without particular effect; and Vinay and Couty found that up to 100 grammes of air could be injected into dogs at one time or in smaller quantities at intervals without fatal effect. In man only small quantities of air are usually aspirated, which oftentimes produces relatively serious results, so that no conclusion can be drawn from experiments on animals.

The cause of death after aspiration of air has not been sufficiently explained. According to Panum, the air which reaches the pulmonary arteries, as an uninterrupted column only slightly mixed with blood, acts as a large embolus that prevents circulation of blood for a moment, deprives the left ventricle of its usual supply, and thereby produces anæmia of the brain. Death is due to suffocation. Another theory assumes that the air accumulating in the right ventricle leads to overdistention of the ventricle and thereby to paralysis of the heart. According to Senn, the mechanism varies in different cases, and the symptoms are due to distention of the heart or to disturbances of the pulmonary circulation. The autopsy reports are not sufficiently reliable to decide this question.

If death does not follow the entrance of air, the air disappears from the circulation, either through the wound in the vein or by becoming absorbed by the blood. Experiments on animals show that small quantities of air may pass through the lung and reach the general circulation.

From the above it will be seen that in operations on the neck the possibility of the entrance of air must always be taken into consideration, and that one should endeavor to be prepared for this by appropriate prophylactic precautions. If a tumor that is adherent to surrounding structures is to be excised, and where in all probability the internal jugular will have to be resected, it is well to follow Langenbeck's counsel, and first expose the vein at the lower margin of the tumor—*i. e.*, at the base of the neck—and place a ligature loosely about it. This ligature may be tightened at once by an assistant should the vein be accidentally injured. If the accident has already happened, then further aspiration of air into the vein must be prevented by immediate digital pressure on the vein in question. To insure safety, one may follow the suggestion of Treves, and flood the field of operation with water (salt solution). The opening in the vein is then definitely closed by double ligatures or by sutures. If the entrance of air is followed by serious symptoms, it is well to try to eliminate the air from the circulation by strongly compressing the thorax during expiration and removing the finger from the opened vein for a moment. Treves claims to have saved 2 cases by this procedure. Senn was able, in animals, to draw off air from the right ventricle by introducing a fine trocar, and from the right auricle by means of a catheter. This method, however, cannot very well be applied to human beings. The most efficient means of meeting the symptoms that appear immediately is to try artificial respiration energetically and for a long time. The cardiac weakness should be combated by rubbing the skin, by camphor or ether injections, and by massage of the heart. In extreme cases bleeding may be resorted to.

Stab- and incised wounds play an important part in the etiology of wounds of veins, whereas in gunshot-wounds the neighboring organs are more liable to suffer at the same time. As with injuries to arteries, the primary hemorrhage after a gunshot-wound of some vein may be slight, and the patient succumbs to secondary hemorrhage and its complications. Bleeding may furthermore be due to erosion of the venous wall in deep-seated suppuration or by malignant tumors. Finally, the veins are not infrequently injured during the removal of tumors of the neck.

The prognosis is grave, but has been much improved since the dangers formerly associated with ligation have practically been done away with (phlebitis, pyæmia).

Double ligation at the seat of injury is the most effective means of avoiding after-results. This is the step to be taken in all cases in which complete occlusion of a vein does not give rise to difficulty. Only when this method is counterindicated for the above reason, or when its execution is impossible for technical reasons, are other methods of hæmostasis, such as tamponing, compression, lateral ligation, and vein suture, justified. When the wound in a vein is small, recovery may follow tamponing with iodoform gauze without obliteration of the lumen. With lateral wounds that are not longer than 4 to 5 mm., lateral ligation may be performed with safety. Silk is the best material for this purpose. When the tear is longitudinal and longer, or when there is transverse solution of continuity not affecting more than a third to a half of the circumference, suture of the vein may be tried. This procedure is strongly to be recommended considering the fairly abundant experience that has thus far been reported. As is shown by clinical observation and by the autopsies performed by Schede, healing of the wound in the vein takes place without the formation of even a trace of thrombus and without material diminution in the lumen of the vessel provided that the wound closes by first intention. Three months after suture of the internal jugular vein the autopsy showed nothing particularly abnormal in one of Schede's cases. The patient died of typhoid. Continuous catgut should be used for sewing. Accurate approximation of the corresponding layers of the wound in the vein is essential.

Closure of wounds of veins by means of clamps, which remain *in situ* several days, is a less reliable procedure and cannot be recommended for general use, although this method has given satisfactory results in the hands of some operators. (Küster.)

LIGATION OF VEINS.

Ligation of the Internal Jugular Vein.—Now that the dangers existing in pre-antiseptic days associated with ligation of large veins no longer exist (secondary hemorrhage after removal of the ligature, extensive thrombosis, pyæmia), the only question that may arise as to the justifiability of ligation is the possibility of producing some mechanical disturbance of the circulation. If the facts be taken into consideration that there are only two veins into which the transverse sinuses empty, and that four large arteries supply the brain, one may assume that occlusion of one of these veins will lead to grave disturbances of circulation. Experience, however, has shown that in the majority of cases effective collateral circulation is established very quickly.

In 91 cases of ligation of the jugular vein collected by Rohrbach, transitory disturbances, such as cyanosis and œdema of the corresponding half of the face, headache, and contraction of the pupil, were observed in only 9 cases, and death occurred in but 1 case. This was a woman, fifty-seven years of age, in whom the left internal jugular had to be resected during excision of a carcinoma of the neck. The patient did not come out of the anæsthetic and died in coma on the sixth day. The autopsy showed very insufficient development of the right lateral sinus and right jugular vein; also foci of softening in both frontal lobes due to venous congestion and secondary arterial anæmia. Of the 90 other cases, 13 recovered completely. Of the remaining 77, 13 died, but not on account of the ligation.

Kummer and v. Bruns (Linser) have added 1 case each to the statistics of death following ligation of the jugular vein, so that now 3 cases in all have been observed. In v. Bruns' second case the lumen of the jugular vein on the other side was abnormally small, which explained the fatal œdema of the brain. Anatomical investigations of Linser on 1022 skulls showed that absolute insufficiency of one jugular vein at its seat of origin was present in 3 per cent. of the cases, and that this abnormality is five times as common on the left side as on the right.

Ligation of one of the jugular veins, even when the wound heals by first intention, must not be considered absolutely devoid of danger, and should be performed only when specifically indicated.

The indications are as follows: 1. Hemorrhage following injury or erosion of the vessel. It must be remembered that when small lateral tears exist, other methods of stopping the wound, such as lateral ligation and suture of the vein, should be considered. 2. Adhesions between the vein and tumors. Collateral circulation has, as a rule, been established because of the long-continued pressure, so that a large section of the vein may be removed without hesitation not only in the case of malignant growths, but also when extensive masses of tuberculous glands have become intimately adherent due to overgrowth of periadenitic fibrous tissue. 3. Aneurism (arteriovenosum). 4. Pyæmic otitis, thrombosis of the lateral sinus, so as to prevent pyæmia.

Ligation of the External Jugular Vein.—This vein can always be tied without fear of after-effects, and when the vessel has been injured this is the method of election.

Ligation of the Subclavian Vein.—Occlusion of this vein makes considerable difference in the circulation of the upper extremity, especially after the loss of much blood. The vessel should be tied only when absolutely indicated. In cases of partial solution of continuity an effort should be made to stop the hemorrhage by suture or by lateral ligation. Collateral circulation is usually established without difficulty, as shown by experience, provided that the circulation is otherwise normal and no thrombus forms at the seat of ligation. The fear of gangrene is unfounded, just as in the case of the femoral vein.

Injuries to the vein alone are uncommon because of its protected position behind the clavicle. In stab-wounds and gunshot-wounds the artery and nerves are usually injured at the same time. Klemm has recently reported a case of stab-wound of the vein below the collar bone with complete recovery after lateral ligation. Subcutaneous opening of the vein by fragments of the clavicle and by erosion of the wall by surrounding pus has been repeatedly reported. Frequently, in removing tumors of this region, a piece of the vein above the clavicle has been resected without untoward result.

The prognosis of injury to this vein is always unfavorable, not only on account of the danger of air entering, but also because of the amount of hemorrhage.

Ligation of the Innominate Vein.—Injury of this vein is no longer considered necessarily fatal. Aside from the case of recovery after a stab-wound reported by Maisonneuve, 2 cases of injury to the vessel in excision of tumors have recently been reported. Ricard cut the right innominate vein while operating on carcinomatous glands; he immediately closed the wound in the vessel with a lateral suture and obtained a perfect result. Brohl was obliged to resect the common jugular, subclavian, and innominate veins in removing a melanosarcoma in the left supraclavicular fossa. The resection was accomplished without special difficulty after preliminary division of the clavicle. No disturbances of the circulation were observed after the operation, probably because collateral circulation was established with ease on account of long-continued pressure.

INJURIES OF THE THORACIC DUCT.

Injury to the duct alone in stab-, incised, or gunshot-wounds is uncommon on account of the deep position of the duct. On the other hand, this structure has been frequently incised, and even divided, while removing adherent growths in the supraclavicular fossa. In a preparation shown by Brinton, the duct subdivided and reunited just before reaching the innominate vein, thereby forming a ring, from the outer side of which three twigs and one twig from the inner side were given off. When the duct is injured, the exuding fluid is frequently not milky, but clear and serous, so that it is probable that in these cases the main duct was not harmed, but rather some of the larger collateral twigs.

The danger associated with injury to this structure is due to the continual loss of chyle from the wound, producing grave disturbances of nutrition, and to the possible results of ligation. Simple incised wounds or lacerations have a tendency to heal rapidly after packing, so that the flow of chyle ceases in a short time. When double ligature is applied to the duct, collateral circulation is established, probably through the right lymphatic trunk. Considering the rarity of this injury, some of the cases reported will be cited.

Wilms injured the duct close to its termination while curetting suspicious tissue after excision of a carcinoma of the right side of the neck. This was followed by a flow of milky fluid mixed with blood. The wound granulated after packing with gauze. The patient died six months later from metastases.

Schönborn (1893) injured the duct while excising a tuberculous, broken-down, adherent mass of glands from the left supraclavicular fossa. Cyanosis and collapse followed, due to entrance of air into the vein. After exposing the seat of injury the duct was tied at both ends and divided between the ligatures. The distal ligature, however, came off, and after the operation a large quantity of chyle emptied itself through the wound, without, however, grave disturbance of nutrition. The flow of chyle gradually ceased after about a week and the wound healed. Symptoms due to air-embolism were manifest for two days.

While removing tuberculous lymph-glands from beneath the sternal portion of the sternomastoid, Schwinn tore one of the larger twigs of the duct, and chyle continued to flow from the wound for some time. The patient beginning to fail, the opening was exposed and clamped. The clamps fell off on the third day. Uneventful recovery.

Brohl, while removing a melanosarcoma, resected the left external and internal jugular and the subclavian and innominate veins, and found in the preparation that a piece of the thoracic duct had also been removed. Recovery followed.

Keen sutured an operative tear in the duct and obtained complete recovery. The secretion was serous in this case. He reports at the same time a favorable result by Phelps, who injured the vein and closed it with forceps. Keen also reports a fatal case one and a half day after operation, observed by Cheever.

On the strength of the cases above reported, injury to the duct must be considered less disastrous than was previously believed, especially if collateral circulation has been favored by pressure of tumors situated around the terminal portion of the duct.

Treatment.—As far as the treatment is concerned, recovery has followed packing, ligation, the use of clamps and sutures. The method to be employed will depend on the size of the tear and the ease with which the seat of injury may be exposed. Double ligation of the duct, however, is to be confined to cases in which division is complete or nearly so. When separation is partial, suture as applied in the case of veins is to be recommended. In small tears, packing with iodoform gauze will in all probability be sufficient.

INJURIES OF NERVES IN THE NECK.

Injuries of the Vagus.—Sudden bruising of the nerve may give rise to serious symptoms, as shown by 2 cases reported. Michaux ligated the pedicle of a lipoma that surrounded the vagus nerve. After crying out the patient became unconscious and breathing ceased. These alarming symptoms disappeared after removal of the ligature. In a case operated on by Tilmann for the removal of a carcinoma of the left side of the neck that was adherent to the jugular vein and the vagus, the patient suddenly became pulseless and ceased to breathe. It was discovered that the vagus had been caught in a clamp which destroyed about three-fourths of the nerve. After removing the clamp, and employing cardiac massage and injection of ether, the attack passed off and the operation was continued without further disturbance of breathing or of the heart action. The nerve was dissected out from the tumor and sutured at the seat of injury. Recovery took place, although the thoracic duct was tied at the same time. Injuries to the nerve alone are rare on account of its protected situation. They are generally due to stab- or gunshot-wounds.

Only 7 poorly described cases of gunshot-wound are to be found in literature: 1 case by Stromeyer and Beck, 3 by Demme, 1 by Blanke, 1 by Traumann (Fischer). In Stromeyer's patient, in whom the ball passed horizontally behind the carotid arteries, the left vagus was bruised by being pressed against the vertebral column; the right vagus was only grazed. On the left side the respiratory murmur was absent. Death followed in three weeks. Of Demme's 3 cases, 2 recovered, but had labored respiration, a hoarse voice, and increased pulse-rate. In the case recently reported by Traumann the vagus was injured below the superior laryngeal nerve by a bullet entering through the mouth. There were motor paralysis of the vocal cords and great increase in the pulse-rate, but no pulmonary signs. Recovery.

The experience with division of the nerve in connection with excision of malignant tumors is more extensive. There are 4 further observations to add to the 19 cases of unilateral resection of the vagus collected by Widmer in 1893 (Gussenbauer, 2; Eigenbrodt, 1, and 1 of the authors). Of these 23 cases, recovery took place in 11, and death in 12, so that the mortality is about 52 per cent. It must, however, be taken into consideration in connection with this death-rate that in all of the cases the large vessels were tied at the same time, and that the patients were usually advanced in years and run down. They were subjected to a protracted operation, and furthermore several of the cases belonged to the pre-antiseptic era. The causes of death were secondary hemorrhage, cerebral embolism following ligation of the carotid, injury to the phrenic nerve, purulent meningitis, delirium tremens, purulent bronchitis, and pneumonia. In none of the cases was death directly attributable to injury of the vagus itself.

These statistics make it justifiable to consider unilateral resection of the vagus a procedure devoid of danger. It must be remembered, however, that in these cases of resection the nerve was not normal as a rule. The vagus should be resected only when it is inseparably adherent to growths. Prolonged compression of the nerve or carcinomatous infiltration has usually preceded operative interference, so that the healthy vagus of the other side has had time to assume the functions of the diseased nerve.

After resection of the vagus laryngeal symptoms are most constantly noted. There is always paralysis of the vocal cords with hoarseness. Sensation of the mucous membrane and motility of the epiglottis remain intact if the vagus is divided below the seat of origin of the superior laryngeal nerve, as is usual. Respiratory changes have not been accurately reported in any case. Stromeyer's case is not available in this respect, because the vagus on the other side was not healthy. The pulmonary complications frequently occurring after the operation might be explained by other causes than ligation of the vagus. Any particular or permanent influence on the heart has not been reported. The pulse remains unchanged in the majority of cases. In Eigenbrodt's and Traumann's patient there was increase in the pulse-rate. No symptoms referable to the digestive organs have been noticed after division of the vagus.

Injuries of the Cervical Sympathetic.—Injuries of this nerve alone are extremely rare on account of its anatomical position. In 1876 Seeligmüller was able to collect 13 cases of injury to the sympathetic nerve that had been more accurately described. Of these, 10 were cases of paralysis and 3, cases of irritation. Among the latter was 1 case observed by Mitchell, Morehouse, and Keen, in which the nerve had been injured by a gunshot, and in which complete recovery took place.

Irritation or paralysis of the sympathetic is more frequently due to compression by tumors of the neck. Irritation causes dilatation of the pupil, widening of the palpebral orifice, protrusion of the bulbus, and pallor of the corresponding side of the face, the surface temperature of which may be lowered. Paralysis, on the contrary, causes myosis, ptosis (by paralysis of the smooth muscle-fibres of the lid), congestion, and increased temperature of that side of the face.

The sympathetic nerve has been resected in the excision of neoplasms. In a case operated upon by Israel the paralytic symptoms occurring immediately after the operation improved in the course of the following week. No interference with the heart has been reported. Division or excision of the sympathetic may therefore be considered a procedure without danger if done on one side, and may be performed without hesitation when the nerve cannot be dissected free from adherent tumors. No instance of suturing the nerve has been reported.

Resection of the sympathetic nerve has been recently recommended for therapeutic purposes, especially for the cure of epilepsy. Alexander recommended bilateral resection of the upper ganglion, Bogdanek of the middle ganglion, and von Jaksch of the lower ganglion, in connection with ligation of the vertebral artery and division of the sympathetic above the ganglion. Junnesco went a step farther and performed bilateral resection of the entire sympathetic for the cure of epilepsy and Graves' disease, and excision of the upper cervical ganglion alone for the cure of glaucoma. As there were no reliable data to justify excision of the sympathetic, the operation had to depend for its justification on clinical results. The results of Junnesco are as follows: Of 45 cases operated for epilepsy, 19 were subsequently examined—10 were cured, 6 improved, and 2 not improved. Of 10 cases operated for Graves' disease, 6 were cured, 4 improved. The observations in none of these cases extend over two years, and are therefore too short to judge of the final results. Resection of the sympathetic should be resorted to only in cases so difficult that any other form of treatment cannot be adopted. According to Braun's more recent experience, resection is without influence on epilepsy.

Injuries of the Brachial Plexus.—This injury generally follows gunshot-wounds, where either the projectile itself or splinters of a fractured clavicle bruise or divide the nerve-cords. There are usually life-endangering complications at the time, especially laceration of the vessels at the root of the neck, so that the damage done to the nerves becomes of less importance. Severe contusions of the supraclavicular region may also lead to paralysis of the plexus. Stabs or incisions in which individual cords are cut are more infrequent. The symptoms depend in each individual case on the location of the wound. The indications for undertaking primary or secondary nerve suture depend on the conditions in the wound and the possibility of accurately determining the paralysis, etc.

Injury of the Spinal Accessory.—In surgery of the neck only the external branch of this nerve will have to be considered, because it is hardly possible to avoid dividing this branch while removing certain tumors. The effects of the injury are not uniform. In a portion of the cases complete paralysis of the sternomastoid and trapezius results, whereas in other cases the function of the muscles is not entirely lost. These differences are explained by the fact that both muscles are not exclusively supplied by the accessory nerve, but also by motor branches of the second to the fourth cervical nerves which join the spinal accessory either before its entrance into the sternomastoid or supply these muscles directly.

CHAPTER III.

DISEASES OF THE NECK.

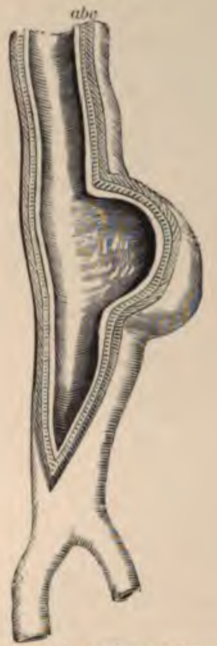
ANEURISMS OF THE NECK.

Arterial Aneurisms of the Neck.

Traumatic or false and spontaneous or true aneurisms occur in the neck. The former develop either immediately after some injury to an artery or appear several weeks or months afterward, due to gradual stretching of the scar in the vessel-wall. The wound in the vessel itself may be produced by a stab or gunshot, and the small skin opening may heal rapidly. There may be subcutaneous rupture following the application of force (kick of a horse, strangulation). Spontaneous aneurisms develop as the result of circumscribed softening of the wall due to arterial sclerosis, advanced age, lues, or alcoholism. The two varieties are not always to be sharply separated clinically. There are transitional and combination types; for instance, a spontaneous aneurism not infrequently develops rather quickly following some slight trauma, owing to rupture of a pathologically soft intima and [illegible]. Traumatic aneurisms, on the other hand, may develop very slowly by gradual distention of a scar in the vessel-wall. As the symptoms and the treatment of both types of aneurism correspond in [illegible], it is not necessary to give them separate consideration. Crisp's [illegible] some information as to the frequency of aneurisms of [illegible] of the neck. Of 551 cases of aneurism in general, 20 were of the innominate, 23 of the subclavian, and 25 of the carotids. Of the carotid, the common trunk is the seat of disease in the majority of [illegible] according to Barwell, in 87.35 per cent. of the cases, whereas [illegible] affect the external and 5.75 per cent. the internal carotid. [illegible]

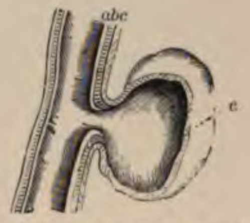
Aneurism of the Common Carotid.—The seat of disease may be at the upper or lower section of the artery; the former, however, is most [illegible] at the seat of bifurcation there is often normally present a [illegible] dilatation. The disease is more common in men and [illegible] during youth. The size of the tumor may vary. It [illegible] the whole side of the neck. The shape is usually oval, [illegible] spherical, and the long axis of the swelling beneath [illegible] corresponds to the direction of the large vessels. [illegible] systolic murmur are usually present, but may be absent [illegible] in the sac. The size of the tumor is always [illegible] pressure, but when this is removed the former dimensions [illegible] regained. The pulse of the temporal artery is

Fig. 19.



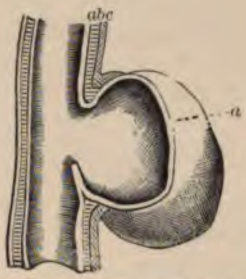
True aneurism: the sac formed by all the coats.

Fig. 20.



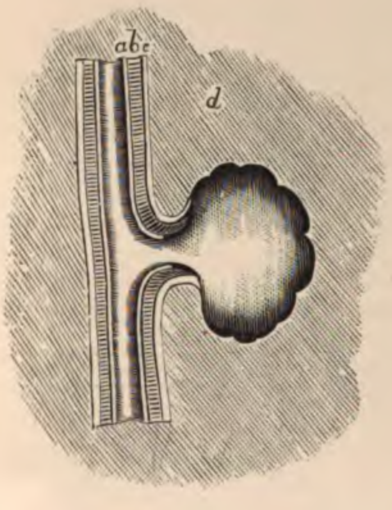
"False" aneurism: the sac formed by the outer coat only.

Fig. 21.



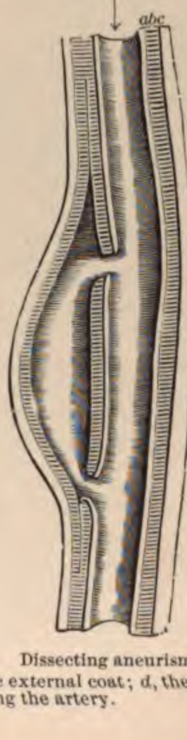
"Hernial" aneurism: the sac formed by the inner coat only.

Fig. 22.



Traumatic aneurism: the sac formed by the tissues around the vessel.

Fig. 23.



Dissecting aneurism.

a, the internal coat of the artery; *b*, the middle coat; *c*, the external coat; d, the cellular tissue, sheath, or other tissues surrounding the artery.

weaker and is somewhat later than that of the other side, but in individual cases may be normal. When the sac is extremely large, symptoms of displacement and compression of the neighboring organs are observed—difficulty in swallowing, dyspnœa, neuralgia, paralysis of the hypoglossal, recurrent laryngeal, or sympathetic nerve. Insufficient blood-supply to the brain may produce headache, dizziness, attacks of unconsciousness, insomnia, and even transitory hemiplegia.

Diagnosis.—The diagnosis is usually easy. The condition may, however, be confounded with other tumors, especially when pulsation is absent—as, for instance, with lymphoma—that are closely adherent to the carotid at the seat of division and surround the vessels in front and behind. Diminution in size on pressure and the presence of paralysis would be in favor of aneurism. It may be much more difficult to differentiate the large blood-cysts communicating with the veins which also diminish in size on pressure. Exploratory puncture does not always decide this point, because in cases of aneurism the needle may penetrate clots from which dark blood will be emptied. Paralysis of neighboring nerves is in favor of aneurism, for this is not usually present with blood-cysts. The accurate localization of aneurisms is quite easy in the upper carotid region, but is often impossible lower down (aneurism of the innominate).

Prognosis.—The prognosis is unfavorable. The aneurism increases but slowly, and may even remain stationary, but it has, generally speaking, a tendency to enlarge progressively. Spontaneous recovery probably never takes place. A fatal result is due either to rupture of the sac (externally or internally with hemorrhage into the trachea, œsophagus, or pleura), or to secondary compression of neighboring organs.

Treatment.—In spontaneous aneurisms, especially those syphilitic in origin, one is always justified in trying internal medication (potassium iodide, diet after Valsalva, Tufnell, Balfour), which not infrequently is followed by lessening of subjective signs and diminution in the size of the tumor. Should this procedure prove unsuccessful, and should there be alarming symptoms of compression, surgical interference will become necessary. In traumatic aneurisms this is indicated from the beginning.

Of surgical methods, compression of the artery, ligation, and radical excision are the first to be considered. The method adopted will depend in the individual case chiefly on the seat of the aneurism, so that it becomes necessary to consider separately aneurisms of the proximal and aneurisms of the distal portion of the artery.

ANEURISM OF THE UPPER PART OF THE CAROTID.—1. *Pressure.*—This is applied over the proximal portion of the carotid—*i. e.*, the lower part of the sac—best with the finger. It is very difficult to apply pressure to an artery alone in the neck on account of compressing other organs at the same time. The artery is occluded daily for a period of several hours. Billroth reports the effect of this procedure. His patient died of pneumonia three years after the cure by digital compression of an aneurism the size of an apple. The cylindrically distended portion of the carotid was filled throughout its course by strand-like coagula adhering closely to the wall. The result most frequently obtained is not complete obliteration of the sac, but a filling up of the same with fibrin, leaving a pervious central canal. Compression is not a distinctive procedure, because the circulation is at the same time maintained. It is less reliable than ligation on account of the possibility of recurrence. As far as the practical results are concerned, Rouge cured 1 case in a man sixty-eight years old, and 3 cases out of 5 collected by Delbet recovered, whereas in the other 2 the tumor remained stationary. Digital compression is not devoid of danger, for brain symptoms may follow occlusion of the carotid. One is, however, in a position to meet this danger immediately by freeing the circulation, thereby avoiding irreparable damage. Billroth's experience in this respect is instructive. In the above-mentioned case, compression gave rise to unconsciousness and convulsions, which disappeared rapidly and recurred with increased intensity, associated with paralysis of the cerebral nerves, when the pressure was reapplied. After eight days these symptoms disappeared and the aneurism was cured. The chances of success are more favorable with traumatic aneurisms than with the spontaneous variety, because in the former the blood is not in contact with any vessel-wall and is more apt to coagulate when the circulation is interrupted. The measure is usually very painful, and at times cannot be carried out. In cases of this sort resort is had to ligation.

2. *Central Ligation below the Sac, after Hunter or Anel.*—This method is much more rapid and accurate than compression. The danger, however, is correspondingly greater, because one of the arteries supplying the brain is suddenly occluded. The conditions that favor formation of collateral circulation are much more developed where an aneurism exists than in healthy vessels, but there is always the possibility that an insufficient amount of blood will be supplied to the brain. In traumatic aneurisms of young people that are otherwise healthy, one does not hesitate to decide upon operation, whereas the prevailing conditions must be taken into consideration in spontaneous aneurisms in those more advanced in years or when the patient is suffering from some constitutional disorder. It is always advisable to determine the effect of compressing the artery before operating, and when symptoms referable to disturbed cerebral circulation are noticed the vessel should not be tied.

The results of ligation have become materially better since the introduction of antisepsis. In the pre-antiseptic era, 21—*i. e.*, 44 per cent.—of 47 cases collected by Le Fort, succumbed; whereas only 2—*i. e.*, 22 per cent.—died of 9 cases collected by Delbet and Walther, since 1875. Death was due in one case to secondary hemorrhage, and in the other to suppuration.

3. *Antyllus Method—i. e., Ligation above and below the Sac, and Excision or Incision of the Latter.*—This is the quickest and surest way of curing an aneurism, but is technically most difficult, as there are often adhesions between the sac and surrounding tissues.

Karewski ligated the common carotid below and the external and internal carotid above the sac of an aneurism the size of a fist in a man thirty years of age, which was probably due to syphilis. The sac was partially resected. Recovery was uneventful. Délagénière excised an aneurism the size of an orange in a girl sixteen years of age after ligating the carotid centrally and peripherally. The internal jugular vein was also tied. Recovery.

A radical operation is more often indicated in young people with traumatic aneurism.

ANEURISM OF THE BEGINNING OF THE COMMON CAROTID.—The treatment is the same as that of aneurism of the innominate. Peripheral compression and peripheral ligation are the only methods of treatment to be considered, because occlusion of the innominate is too dangerous.

Aneurism of the External Carotid.—Aneurisms of the external carotid are uncommon, as already mentioned, and are usually due to traumatism. The tumor is situated below the angle of the jaw and presses upon the neighboring nerves (hypoglossal, glossopharyngeal, accessorious), and displaces the tonsil inward. When compression does not give the desired result, the vessel should be tied. Only when the sac reaches the seat of bifurcation is one obliged to tie the common carotid, which is not without danger in cases of this sort. In a case reported by Heith in a man twenty-three years of age operated upon by Hunter's method, death followed several weeks after the operation from embolism of the arteria fossæ Sylvii.

Aneurism of the Internal Carotid.—There are but few observations reported on aneurisms of the extracranial portion of the internal carotid. The swelling is situated between the angle of the jaw and the ear, and protrudes into the pharynx, and may be confounded with a tumor or abscess of the tonsil or of the lateral pharyngeal wall. A central ligature to the internal carotid or to the common carotid should be applied. Wyeth succeeded in curing a woman sixty years of age by tying the internal carotid and then the external carotid below the point of origin of the lingual; the superior thyroid was tied at the same time.

Aneurism of the Innominate Artery.—Stab-wounds of this artery are probably always fatal, therefore the traumatic variety need not be considered. The etiology of spontaneous aneurism presents no special points of interest. The condition may develop in any part of the vessel, but only the variety situated in the peripheral portion need be considered here. This appears as a swelling in the lower portion of the neck. In its growth the tumor, at first intrathoracic, gradually spreads above the sternum into the lower region of the neck, protruding between the sternal part of the sternomastoid and the trachea. The ordinary signs of aneurism are present. Usually, symptoms of pressure upon the neighboring organs develop very soon, such as difficulty in swallowing, dyspnœa, hoarseness (paralysis of the recurrent nerve), neuralgia of the brachial plexus or paralysis, œdema of the neck, face, or arms, and at times subluxation and erosion of the clavicle. The vessels leaving the aneurism, the carotid and subclavian, may be obliterated either individually or both at the same time. This is said to have led in some cases to spontaneous cure. On the other hand, the left carotid and subclavian may be obliterated, probably by pressure of the sac. This fact must be taken into consideration in the treatment.

Diagnosis.—The diagnosis, as far as the nature of the tumor is concerned, is easy, but it may be difficult to determine the exact seat of the aneurism, because the clinical picture of an aneurism of the beginning portion of the carotid and of the subclavian may be almost identical. Simultaneous modification of the temporal and radial pulse points to involvement of the innominate.

Treatment.—Stewart and Salinger obliterated the sac almost completely by electrolysis in a man forty years of age. The patient was still alive after three years. Macewen's method gave a favorable result in a case of Bäumler. This patient had an aneurism of the innominate and neighboring portion of the aorta. Both carotids had been obliterated. The right subclavian had been ligated without success. After introducing a needle thirteen times, and leaving the needle in place each time from six to eight hours, the swelling, which was the size of a hen's egg, gradually became flatter and after a year's time disappeared. Only the large arteries leaving the aneurism are of interest surgically, because for anatomical reasons they alone can be ligated. By tying these the aneurism is shut out of the circulation as it were, and the blood in its interior gradually becomes coagulated. The peripheral collateral circulation is established through anastomoses between the external carotid arteries. If this method is to be successful, the left carotid must be intact. This should be ascertained before ligating. Guinard lost a patient five days after the operation from hemiplegia, and the autopsy showed obliteration of the left carotid. Collateral routes are more or less developed as a rule, owing to the pressure of the aneurism, and therefore the danger of seriously disturbing the circulation in the head and arm is not great. As a matter of fact, such conditions have not been observed except in Guinard's case. The carotid alone, as well as the subclavian, has been tied, and both arteries have been tied on one or both sides. According to the statistics of Rosenstirn in 1897, simultaneous ligation shows the best results: 14 cases were cured and 18 died (25 per cent. mortality) out of 32 cases operated upon since the introduction of asepsis. Considering the gravity of the disease and the difficulty of the operation, the results of Brasdor's ligation are very favorable, as shown by the following table of 69 cases prepared by Jakob and including the years from 1870 to 1892. Of these 69 cases, 36 were cured; 29 were under observation for more than one year. Considerable improvement in 7 cases; no improvement in 4 cases. Twenty-two patients died within three months after the operation; the cause of death being in 8 cases sepsis, in 4 rupture of the sac, 3 died of the anæsthetic, 1 of hæmoptysis, 1 case of shock, and in 5 cases the cause was unknown. The cases reported since 1892 probably show much more favorable results. Of 10 operated cases, 8 were cured, 1 was temporarily improved, 1 died (1 case of Bardeleben, 1 of Winslow, 1 of Mariot, 6 of Guinard, 1 of Le Dentu). In all of these cases the carotid and subclavian were tied at the same time, which is to be considered the operation of election.

For the purpose of simply uncovering the arteries and leaving the aneurismal sac, Mott's incision for ligation of the innominate artery, with resection of the sternal portion of the sternomastoid, is probably best adapted for exposing the field of operation.

Aneurisms of the Subclavian above the Collar Bone.—Traumatic aneurisms are rare. This condition was noticed 6 times in 13 cases of stab-wound of the artery collected by Rotter. Billroth reports 2 cases after subcutaneous rupture of the artery following the kick of a horse and a fall on the shoulder. Both patients died of acute anæmia associated with marked increase in the size of the sac. The autopsy showed that they had bled to death into the sac.

A cervical rib may be the predisposing cause of spontaneous aneurism. Other than this there is nothing worthy of especial mention in the etiology.

The aneurism may be of the beginning portion of the subclavian or of the portion beyond the scaleni. The former, which is almost always on the right side, corresponds, as far as symptoms are concerned, with an aneurism of the innominate in general, and is treated in the same way. Aneurisms of the distal portion press upon the brachial plexus and produce symptoms of irritation or paralysis. The veins of the neck may be compressed or the clavicle may be displaced. The radial pulse is smaller and later than that of the other side—a symptom of great differential diagnostic importance.

Prognosis.—The prognosis is unfavorable. Death is usually due to rupture.

Treatment.—In aneurisms of the first portion compression below the sac may be tried, and followed, if need be, by ligation as recommended by Brasdor. In aneurisms of the terminal portion central compression is sometimes successful. This was the case in the above named patient of Schally's, where a considerable shrinking of the sac took place. Of the operative methods, ligation after Anel or double ligation after Antyllus, or excision of the sac, may have to be considered. Miles successfully tied the subclavian centrally and the axillary at the distal margin of an aneurism following a gunshot-wound.

Aneurism of the Vertebral Artery.—The position of this artery between the scaleni muscles and the longus colli and then in the bony canal of the vertebræ, in the beginning of its course, does not favor the formation of spontaneous aneurisms. As yet but one case has been reported (Mikulicz's clinic), by Hufschmidt, in 1896. The sac was situated in the lower part of the artery before its entrance into the spinal vertebræ. The patient was a man fifty-eight years of age, with general atheroma. There had been slight injury previously. The diagnosis was made by pressure experiments. The vertebral artery was ligated close to the subclavian and divided. This was followed by disappearance of the aneurism.

Traumatic aneurisms are rare. Matas was able to collect but 20 cases in 1894 of aneurisms of the extracranial portion of the artery, 6 of which were cured by operative interference. As a rule the only possible method of tying the artery is that recommended by Hunter. This may be followed by incising and packing of the sac.

Arteriovenous Aneurisms.

Arteriovenous Aneurism of the Common Carotid and Internal Jugular.—This variety is very rare. Only 20 cases could be collected, 16 of which were in Pluyette's statistics in 1886 and 13 in Bramann's (1886), and 4 scattered cases were found in modern literature. The primary causes were stab-, incised, or gunshot-wounds. Of the 16 cases reported by Pluyette, 7 were stab-wounds, 2 were gunshot-wounds, and 1 was produced by fragments of glass. Of Bramann's cases, 4 were stab-wounds, 5 gunshot-wounds, and 3 incised wounds. This etiology explains why the condition is found exclusively in men from twenty to sixty years of age, and why the condition is more frequent on the right side of the body. It has not been definitely proved that arteriovenous aneurisms may be due to erosion of a vein by an arterial aneurism. Following the injury there is more or less violent hemorrhage that ceases as the result of cardiac weakness, or is controlled by pressure. A short time after the patient has recovered, one to eight days after the injury, or rarely later, characteristic signs of aneurism are noticed. The blood first pours out through the wound in the vessel, and owing to the small size of the external wound or on account of obstruction in the course of the wound, bleeding takes place into the tissues (interstitial hæmatoma). The arterial blood under pressure breaks through into the opening in the vein. This event is favored by the negative pressure in the vein and the aspirating power of the chest. The margins of the wounds in the vessels may at times unite, because the vein and artery are so near in the common sheath. When this takes place, there is no intervening aneurismal sac. From a clinical standpoint it is well to differentiate aneurismal varix from an arteriovenous aneurism proper, because both types present certain differences as regards symptoms, prognosis, and treatment.

Symptoms.—At the seat of injury, usually indicated by marked ecchymosis, there is a swelling of varying size, which pulsates distinctly. In aneurismal varix the tumor is always circumscribed, oval or hemispherical, of soft, fluctuating consistency, and may be obliterated entirely by direct pressure. In arteriovenous aneurisms, on the other hand, the shape of the tumor is irregular, it is of firmer consistence and may be diminished by pressure but not entirely obliterated. A continuous murmur, increasing in systole, may be heard with the stethoscope. The intensity of this murmur diminishes in both directions. Corresponding to this murmur a prolonged thrill increased in systole may be felt on palpation. These sounds disappear when pressure is brought to bear upon the tumor or when the carotid is compressed centrally. The pulse is weaker than on the other side. The subcutaneous veins on the side affected are frequently dilated. Owing to the obstruction to the flow of venous blood cerebral symptoms arise, such as headache, dizziness, fainting fits, and impaired memory. As a rule, these disturbances disappear when collateral circulation is established. In individual cases, however, grave disturbances, such as pareses, psychical depression, difficulty in hearing, and weakness of eyesight, have been observed. A very annoying symptom is the continual roaring in the tumor, appreciated by the patient himself. This deprives him of sleep and makes him unfit to work. Pressure of the aneurism on the vagus may finally give rise to cough, hoarseness, and shortness of breath.

Prognosis.—According to the observations thus far reported, the secondary symptoms existing at the start gradually disappear. The tumor may remain stationary many years and not disturb the patient to any great degree, so that he is enabled to go about his duties. Aneurismal varix is not directly dangerous to life, and an arteriovenous aneurism is only slightly so (rapid growth, rupture of the sac). Pluyette mentions that of the 16 cases reported by him, 13 that were not operated upon lived from thirteen to twenty-seven years. Thiéry recently presented a man in the Paris Surgical Society, who was suffering from arteriovenous aneurism of the left side of the neck, following a gunshot-wound. The above-mentioned cerebral disturbances were only temporary, so that there was no indication to operate. The ball was located at the level of the third cervical vertebra by means of the *x*-rays.

Treatment.—The formation of aneurism can, as a rule, be avoided by proper treatment of recent injuries. In existing aneurisms the indication for operating is only relative. One should interfere when the tumor grows rapidly or gives rise to severe symptoms, or when the patient himself demands that it be removed. It is always advisable to try digital compression of the carotid below the sac. If this does not give the desired result within a few days, ligation may be resorted to after making sure that occlusion of the carotid will not give rise to cerebral symptoms. The best method of obtaining a cure is to ligate the artery and the vein above and below the aneurism and subsequently excise the sac. If there are many adhesions to the surrounding tissues, one should be satisfied with double ligation of the vessels, incising and packing the sac. Keen cured a boy sixteen years of age by this method; and Heinecke reports a case of cure after double ligation of the carotid, incision into the intervening portion, and tamponing of the jugular opening. Ligation of the carotid alone is an unsafe procedure. Of 3 cases operated on by Hunter's method mentioned in Pluyette's and Bramann's statistics, 2 died and no improvement was noticed in the third.

Considering the favorable results recently reported with suture of arteries and veins, it might be justifiable in cases of aneurismal varix, especially where the communicating opening is very small, to try to close the opening with a suture after provisional clamping of the vessels both peripherally and centrally, and division of the communication.

Arteriovenous Aneurism of the External Carotid and Internal Jugular Vein.—This condition is extremely rare. A typical case has been recently reported by Postempsky. An aneurism the size of a hen's egg developed in connection with a wound that had apparently healed. This proved on excision to be an arteriovenous aneurism of the external carotid and internal jugular. After ligating both vessels above and below the sac, the carotid proximal to the origin of the thyroid superior and distally to the external maxillary, the aneurism was excised. Complete recovery.

Extracranial Arteriovenous Aneurisms of the Internal Carotid.—These conditions are also very rare. In a case reported by Giraldès, the aneurism followed a gunshot injury. The patient died of a carbuncle six weeks after the accident, and on autopsy the ball was found in the small sac joining the artery with the internal jugular vein. Joret reports a similar case in which the ball was found encapsulated in connective tissue in the internal jugular vein behind the angle of the jaw one and a half years after the injury. Death occurred with symptoms of softening of the brain and epilepsy.

Arteriovenous Aneurisms of the Subclavicular Vessels.—Very few cases of aneurisms of this sort have been reported, for injury of the vessels alone is uncommon and usually fatal. Six cases are recorded in literature, 3 of which followed stab-wounds and 3 gunshot-wounds. One characteristic case is reported by Veiel. This aneurism, nearly as large as a hen's egg, was produced by a stab that touched the lower margin of the artery and the upper margin of the vein. Nine days after the injury Veiel ligated the artery and vein above and below the sac, recovery taking place without damage to the arm. As regards symptoms, prognosis, and treatment, the same remarks apply as to aneurism of the carotid.

INFLAMMATIONS OF THE NECK.

Acute Inflammatory Processes in the Neck.

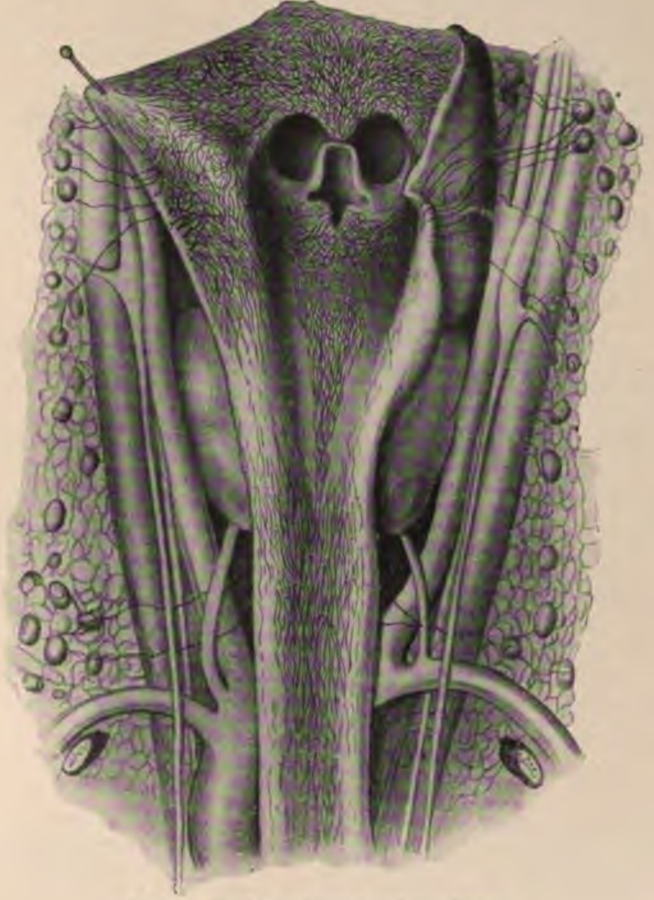
Boils and Carbuncles.—Boils and carbuncles are especially common in the neck, for friction of the collar favors entrance of staphylococci into the hair-follicles and sebaceous glands. The back of the neck is the seat of election. The skin here is abundantly supplied with sebaceous and sweat-glands and is thick and firm. This density is the cause of a great deal of pain and extensive necrosis, because of the pressure of inflammation on the resistant tissues. Lymphangitis and lymphadenitis of the glands situated at the posterior margin of the sternomastoid may be followed by abscess. Secondary infection of neighboring hair follicles produces multiple boils. Furunculosis in this region is often resistant to treatment and may last for months. In the early stage the pustule may be punctured with a pointed cautery and an attempt made to prevent the formation of a boil. If a slough has formed local leucocytosis and localization are favored by warm moist antiseptic poultices (aluminum acetate, weak corrosive sublimate solution). When there is considerable adjacent inflammation, the safest way of diminishing the tension on the tissues is to make liberal incisions to limit the amount of necrosis and diminish the pain. If lymphangitis is present with swelling of the neighboring glands, immediate incision into the primary focus is indicated. Besides local antiseptic dressings, the general treatment is important. This consists in the use of corrosive sublimate baths (2 grains to a bath), sulphur baths, regulation of the bowels by cathartics, and administration of salol and salicylic acid (internal antisepsis.) If examination of the urine, which should never be neglected, shows the presence of sugar, a suitable diet should be prescribed in addition to the surgical treatment.

The same rules apply to the treatment of carbuncles, except that the incisions must be more liberal if the process shows a tendency to extend. If needs be, a crucial incision reaching into the healthy tissues must be made with a knife or cautery. The wound is then packed with iodoform gauze soaked in a solution of aluminum acetate, or [illegible] tincture of iodine, and a moist dressing applied.

Erysipelas. Erysipelas may develop in any wound in the neck. [illegible] in the neighborhood, especially on the face, and [illegible] differences from the same disease in other parts [illegible]

Suppuration and Abscesses. Acute suppuration and abscesses in [illegible] Direct infection of a wound [illegible] the œsophagus or [illegible] extension from neigh- [illegible] cases of suppura- [illegible] tis, purulent [illegible] periostitis of the [illegible] system micro- [illegible] and then invade [illegible] producing bacteria are found, such as pneumococci, *Bacterium coli communis*, typhoid bacilli, and anaërobic bacteria. Suppuration in the neck in itself differs in no way from suppuration in other parts of the body. There are, however, certain peculiarities owing to the anatomical relations in the neck. The situation of the lymph-glands and the arrangement of the connective-tissue planes are of considerable importance, and it therefore seems appropriate to refer briefly to the anatomy of this region, so that the clinical conditions may be better understood.

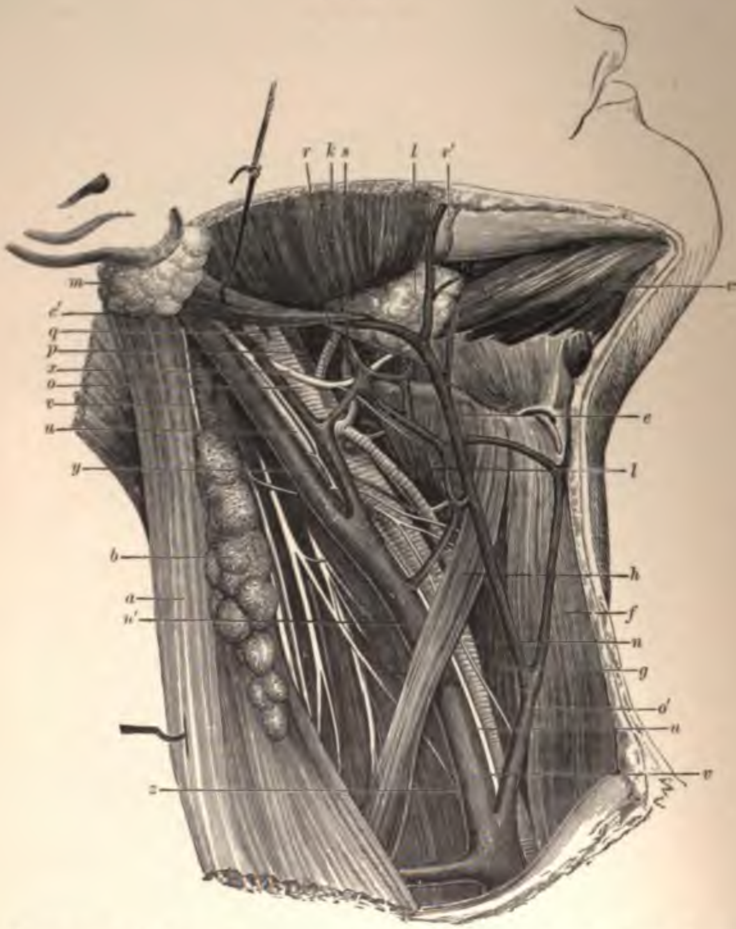
FIG. 24.



Lymphatics of the pharynx and œsophagus.

The margin of the trapezius divides the neck into a posterior region, or nape, and an anterior region, the neck proper. This latter portion is divided by the sternomastoid into a lateral region and an anterior region, between which is the sternocleidomastoid region. The anterior region of the neck, again, is divided by the hyoid bone into a suprahyoid and an infrahyoid region. The infrahyoid region may be divided into a median portion with the subdivisions subhyoid, laryngeal, thyroidal, suprasternal, and a lateral portion where the vessels are found, the carotid region, also termed the upper carotid triangle or the upper

FIG. 25.



a, *M* sternomastoid, insertion cut, anterior edge pulled backward; *b*, lymph-glands; *c*, anterior belly of digastric; *c'*, posterior belly; *e*, *M.* thyrohyoid; *f*, *M.* sternohyoid; *g*, *M.* sternothyroid; *h*, *M.* omohyoid; *i*, *M.* scalenus anticus; *k*, *M.* masseter; *l*, submaxillary gland; *m*, parotid; *n*, common carotid; *o*, external carotid; *p*, internal carotid; *q*, origin of occipital artery; *r*, facial artery; *s*, lingual artery; *t*, superior thyroid artery; *n*¹, internal jugular vein; *o'*, external jugular vein; *u*, vagus; *v*, cervical nerves; *x*, hypoglossal; *y*, loop between the descendens cervicalis and twigs of the cervical plexus; *z*, phrenic nerve. (From the *Nouveau Dictionnaire de médecine et de Chirurgie pratiques.*)

cervical triangle. In the lateral region of the neck between the diverging bellies of the trapezius and sternomastoid, above the collar bone, is the supraclavicular fossa, filled with fat. The posterior belly of the omohyoid, running from the outside below inward and upward to the margin of the sternomastoid, bounds with the sternomastoid and the clavicle a triangle known as the inferior triangle of the neck.

The skin of the neck is closely adherent to the platysma, and can be lifted off only in folds of considerable size along with this muscle. Below this muscle there is loose connective tissue, the superficial fascia. The deep fascia of the neck and its relation to the spaces which it bounds are given differently by different authors. Merkel describes a deep cervical fascia and the aponeurosis of the neck proper. The former is a sheath of connective tissue, covering the prevertebral muscles and joining the sheath of the great vessels of the lateral region of the neck (prevertebral fascia). The aponeurosis of the neck is a very firm layer of connective tissue, reaching from the hyoid bone to the sternum and clavicle, and attached to the sternum as two layers, between which is a small pocket filled with fat, the interaponeurotic suprasternal space. In the middle line it covers the depressors of the hyoid bone (pretracheal fascia). Laterally it covers the great vessels above the tendon of the omohyoid and is then lost, whereas below the tendon it supplies the muscle with a sheath. The anterior surface is subcutaneous in the median line in the neck. Laterally it is covered by the sternomastoid. This membrane may be made tense owing to its close connection with the depressors of the hyoid bone, and the veins of the neck situated below, especially the internal jugular, may thus be held open. This fascia is closely attached to the underlying vessels of the neck, although the vein alone is directly adherent. The arteries, the nerves, and the lymphatics are surrounded by loose connective tissue that is adherent posteriorly to the vertebral column and is continuous with the deep or prevertebral fascia. A superficial layer of the cervical fascia, which, according to the general conception, arises from the median line and covers the sternomastoid, the supraclavicular fossa, and finally forms a sheath for the trapezius or is continuous with the inferior layer of the sheath of this muscle, does not exist, according to Merkel. In the suprahyoid region a dense connective-tissue membrane reaches from the margin of the jaw to the hyoid bone, and covers the sternomastoid laterally. This overlies the submaxillary gland and forms its capsule. Between these layers of connective tissue themselves, as well as between them and the structures of the neck, there are interspaces that contain loose connective tissue. These are very important in suppurative processes, as injection experiments by König and Poulsen have demonstrated. The following spaces are of surgical importance: 1, the retrovisceral space; 2, the previsceral space; 3, the carotid sheath; 4, the suprasternal interaponeurotic space; 5, the capsule of the submaxillary gland. The retrovisceral space is situated between the pharynx and œsophagus in front and the prevertebral fascia behind, beginning at the base of the skull, continuous below with the thoracic cavity, and extending laterally as far as the sheath of the great vessels. The previsceral space lies between the anterior surface of the trachea and the depressors of the hyoid bone. This is bounded in front by the aponeurosis of the neck and is continuous below with the anterior mediastinum. Laterally it reaches the great vessels. Poulsen's experiments have shown that considerable pressure may produce a communication between these spaces. Suppuration in the above-mentioned spaces arises from the surrounding organs (pharynx, œsophagus, vertebral column, thyroid gland), and will therefore be considered in another section of this work. The sheath of the great vessels—*i. e.*, the connective tissue surrounding these vessels—is of great importance in inflammatory processes on account of the large number of lymph-glands it contains. These processes may be very extensive owing to the resistance offered by the overlying cervical aponeurosis. The submaxillary space is the anterior and lower region of the digastric triangle not occupied by the submaxillary gland. This corner is filled with loose connective tissue. The posterior half of the mylohyoid muscle, oftentimes surrounded by glands, presents in this space. The connective tissue is more dense externally, forming the capsule for the gland, and extends from the margin of the jaw to the hyoid bone. Internally it is continuous with the connective tissue of the lateral wall of the pharynx, of the tonsil, and of the sublingual gland. The suprasternal space, reaching from the incisura semilunaris of the sternum to the level of the isthmus of the thyroid gland, contains fat with a few scattered glands, and is traversed below by a transverse anastomosis between the external jugular veins. It bears no relation to surrounding organs, and an abscess developing here tends to remain localized and does not infiltrate neighboring parts.

The lymphatic glands of the neck are arranged in groups: The submaxillary lymph-glands number eight or ten, scattered in the digastric triangle; the more superficial are situated along the margin of the jaw, and sometimes one is found on the external surface of the jaw. The deeper set are in the loose connective tissue between the ramus of the jaw and the mylohyoid muscle, outside the capsule of the submaxillary gland. Inside of this capsule are a few glands, but, according to Merkel, there are no lymph-glands in the substance of the submaxillary as in the parotid gland. These glands receive the lymph of the whole face, of the entire interior of the mouth, of the teeth, of part of the tongue, and of the pharynx. The submental glands are two or three situated in the fat between the anterior bellies of the digastric, some superficial and others deeper on the surface of the mylohyoid muscle. They are connected with the submaxillary glands and receive their lymph from the median portino of the lower lip, the tongue, and the region of the chin. The superficial cervical glands, five or six in number, are covered by the platysma, and are situated on the sternomastoid or behind its posterior margin close to the external jugular vein. They are connected with the submaxillary, occipital, and subauricular glands, and receive the lymph-vessels of the front and back of the neck, as well as those from the external ear. Their vasa efferentia go to deep glands of the neck. The deep glands of the neck, ten to twenty, reach from the base of the skull to the supraclavicular fossa along the great vessels of the neck, and are divided into a superior and an inferior set. Several of the former are situated at the seat of division of the carotid. They receive the lymph of the gums, of the tonsils, of the nasal cavity, of the larger part of the tongue, and of the pharynx and larynx. Others are farther back and lower down near the jugular vein, and receive the lymph-vessels of the cranial cavity, of the lower part of the pharynx, and of the deep muscles of the front and back of the neck. The inferior set of glands is situated in the supraclavicular fossa on the scaleni muscles and around the brachial plexus, and receive all the lymph-vessels of the head and upper neck as well as lymph from the skin and muscles of the lower part of the neck, the lower portion of the larynx, of the thyroid gland, of the trachea, and of the œsophagus. Their vasa efferentia are connected with the neighboring glands of the chest-wall and axilla. The vessels leaving the inferior set of glands unite to form a large trunk, the truncus lymphaticus jugularis, which on the left side joins the thoracic duct and on the right side unites either with the truncus lymphaticus communis or empties independently into the angle between the subclavian vein and the internal jugular.

The suboccipital glands, already mentioned, are situated near the insertion of the trapezius, and receive their lymph from the posterior portion of the scalp. The subauricular glands are found near the insertion of the sternomastoid, and receive lymph from the posterior portion of the ear and the adjoining region of the scalp. The vasa efferentia of these glands open into the superficial cervical set.

Symptoms.—Suppuration is most frequent during youth; according to Poulsen, between the sixteenth and thirtieth year. The reason for this predominance in the early decades of life is probably the greater frequency of peripheral diseases, such as caries of the teeth and sore throat, during this period. Males are somewhat more frequently affected than females. Both halves of the neck are attacked with about equal frequency. Of 530 cases collected by Poulsen, 242 were on the right side, 246 on the left side, and of the remaining number the median group was most frequently involved.

Suppuration may be of any degree, but in the majority of cases it is limited to the formation of an abscess. On account of the anatomical relations it will be necessary to consider the region separately.

SUBMAXILLARY SUPPURATION.—Submaxillary suppuration with abscess is most common. According to Poulsen's statistics, nearly half of the cases of inflammation of the neck occur in this region. The inflammation may extend from the neighborhood or the glands may become involved secondarily to carious teeth, periostitis of the roots, ulceration of the gums, or lesions on the face. In the majority of cases the inflammation manifests itself outside the capsule of the gland. A tense and very tender swelling appears, filling the inframaxillary region, reaching backward to the margin of the sternomastoid, forward to the chin, and downward as far as the hyoid bone. The skin becomes reddened, the pain increases, softening takes place, and the pus finally breaks externally. The effect on the general condition is slight.

In relatively few cases the connective tissue in the submaxillary space is attacked by inflammation. Because of the deep seat of the process, the great pressure, owing to the dense surrounding fascia under which the inflammation progresses, and the relation of the capsular space to surrounding organs, a typical and oftentimes fatal condition develops. In 1838 Ludwig, of Stuttgart, called attention to this condition, which explains the name given, Angina Ludwigii. In practice this term is frequently applied to conditions not coming under this head. The subject will therefore be considered in detail.

Angina Ludwigii may occur at any period of life, but more frequently between the twentieth and thirtieth year, and is especially common in males, as shown by the 31 cases in Leterrier's statistics. The primary focus of infection is usually decayed teeth, ulcers of the mucous membrane, or inflammation of the tonsils. The few lymph-glands situated inside of the capsular space are probably quite frequently the primary seat of disease. (v. Thaden.) Bacteriological investigation gives some information regarding the etiology. In 2 cases streptococci were found, in one *Staphylococcus aureus*, in a further case a bacillus which was not accurately described (Leterrier), and in 4 cases recently examined by Gasser very virulent streptococci and *Bacilli coli communis*. As far as the anatomy is concerned, autopsies and operations have shown that the salivary gland remains intact, but that the surrounding connective tissue is infiltrated with pus and is frequently necrotic. The neighboring connective tissue of the floor of the mouth, of the larynx and pharynx shows extensive inflammatory œdema. The symptoms are much alike in different cases. Following toothache or a slight sore throat there are usually a chill, high fever, and marked constitutional symptoms. Difficulty in swallowing and breathing develops rapidly, and a tense swelling, extremely sensitive to touch and not sharply outlined, is noticed in the submaxillary region. At first the skin is unaltered, but becomes œdematous after several days. The head is held to the affected side and motion avoided. The mouth can hardly be opened the breadth of a finger. The floor of the mouth is much swollen, elevating the tongue and pressing it against the roof. Chewing is impossible. There are increased flow of saliva and foul breath. Death may take place after a few days of continued high fever and severe septic symptoms. In other cases a fatal result follows extension of inflammatory œdema to the larynx. In milder cases an abscess is formed and the pus breaks externally or into the mouth, which event is followed by rapid disappearance of symptoms.

Diagnosis.—The diagnosis is usually easy. Tense swelling in the suprahyoid region, elevation of the floor of the mouth, difficulty in breathing, and severe general infection will be significant symptoms. Osteomyelitis, periostitis of the lower jaw, and extracapsular submaxillary suppuration are to be considered in the differential diagnosis. In the former the swelling is situated on the jaw itself and spreads more toward the face; in the latter the local as well as the general signs are less pronounced and the floor of the mouth is not raised.

Prognosis.—The prognosis in deep-seated submaxillary inflammation is always grave. In any individual case it depends on the virulence of the bacteria and on the treatment. Recovery followed prompt incision in 7 cases recently observed by Delorme. In former times, when operative interference was not practicable, more than half the cases died.

Treatment.—The safest manner of treating the condition is to incise the seat of inflammation freely through the skin. As the severity of the condition is at times determined by the pressure to which the inflammatory exudate is subjected, an incision should be made even when no fluctuation can be detected. The more rapidly the general symptoms develop, the sooner should the region be incised. The cut should be made about a finger's breadth below the margin of the jaw, parallel to the same. After dividing the skin and platysma it is best to work through the infiltrated tissues with a blunt dissector because of the proximity of the large vessels. At times it may be necessary to divide some of the fibres of the mylohyoid, and tracheotomy may be indicated when the dyspnœa becomes dangerous.

ABSCESS AT THE ANGLE OF THE JAW.—Inflammation and abscesses are not infrequently noted at the angle of the jaw in connection with the appearance of a wisdom tooth, and are caused by ulceration of the mucous membrane in the vicinity. There is great difficulty in opening the jaw (phlegmon sous-angulo-maxillaire, Chassaignac.)

SUBMENTAL INFLAMMATION.—Submental inflammation usually takes origin in the submental glands, ,which become infected from rhagades of the lips, ulcers of the frenum of the tongue, and from boils in the region of the chin. The abscess is circumscribed, has no tendency to spread, and heals quickly after incision. The cut is made vertically in the median line.

INFLAMMATION AND ABSCESSES IN THE CONNECTIVE TISSUE SURROUNDING THE GREAT VESSELS (VASCULAR SPACE).—These are next in frequency to submaxillary abscesses, and, like these, usually arise from lymph-glands, especially from the cervical glands. Angina is the chief factor in the etiology. This was the cause 62 times in 117 cases collected by Poulsen. Other sources of infection are decayed teeth, ulcers on the head, otitis, ozæna, and stomatitis. This type of inflammation develops most frequently following the sore throat of scarlet fever, usually during convalescence. A swelling appears beneath the sternomastoid, and is associated with high fever and a great deal of pain. The indurated area corresponds in outline and extent to the muscle. Later, the muscle itself may become infiltrated and suppurate. The head will be held as in wry neck. Œdema, difficulty in opening the jaw, dysphagia, and dyspnœa may develop, owing to the great tension of the exudate beneath the fascia. In scarlet fever the infiltration sometimes subsides spontaneously, although enlargement of the glands persists for a long time after the swelling has disappeared.

As a rule, however, an abscess is formed, and the pus tries to escape at the anterior or posterior margin of the sternomastoid. It perforates the fascia at one of these places, and spreads beneath the platysma as far as the suprasternal notch, into the supraclavicular fossa, or even into the armpit. Extension into the anterior mediastinum, pharynx, oesophagus, or trachea is rare. If the inflammation is of the upper set of glands, then the swelling will appear at the anterior margin of the sternomastoid, behind the angle of the jaw. If the lower glands are involved, the infiltration will be localized more toward the posterior margin of the muscle, in the lateral region of the neck.

Prognosis.—The prognosis of circumscribed abscesses of the vascular sheath is grave on account of the complications possible. Provided the treatment is appropriate, the chances of recovery are fairly good. Only 2 of the 117 cases reported by Poulsen terminated fatally (ulceration of the vessels).

Treatment.—An effort may be made in the beginning to aid resolution by applying moist warm poultices and by painting with tincture of iodine. When the presence of pus seems probable, judging from the intensity of the local inflammatory signs, it is well to incise the region immediately so as to stop the process and avoid dangerous complications. The incision should be made along the anterior or posterior margin of the sternomastoid. The subsequent manipulations require great care on account of the vessels in the vicinity. Counteropenings should be made if there is any tendency for the pus to infiltrate the lower regions of the neck.

ABSCESSES OF THE SUPRACLAVICULAR FOSSA.—These usually develop from the inferior deep cervical glands or are due to infiltration downward of pus from an abscess in the region of the vessel-sheath. The tumor will be found between the sternomastoid and the trapezius. The pus may perforate the platysma and reach the surface quickly, or it may spread out in the connective tissue around the vessels or follow along the sheath behind the clavicle down into the axilla. When this happens, symptoms due to pressure upon the vessels quickly appear.

DIFFUSE CELLULITIS.—Diffuse cellulitis may follow circumscribed suppuration in any part of the neck, or it may develop primarily when the virulence of the infecting organism is great and the resistance of the individual is diminished on account of some constitutional disturbance or during the convalescence from some acute disease. This is the reason why the most severe types of inflammation occur in children after scarlet fever and in alcoholics and debilitated adults suffering from phthisis, diabetes, or malignant tumors. Inflammation within the sheath of the great vessels is most malignant, and is spoken of as deep suppuration of the neck. An extremely painful swelling develops quickly, and the indurated area may reach from the ear to the collar bone and from the nape of the neck to the larynx. The skin gradually reddens; there are wry neck and difficulty in opening the jaw. Symptoms of severe general infection are present from the beginning. There is diffuse purulent infiltration and sometimes necrosis of the connective tissue. In many cases death from sepsis takes place before the formation of an abscess. When the course is less acute, the infiltrated area softens and pus is formed in the interior. The abscess may extend to the mediastinum or into the axilla, or may press upon the trachea, the œsophagus, or the great vessels and nerves, and cause death in this way. In rare cases the abscess ruptures through the skin and spontaneous recovery may follow. The prognosis is unfavorable. The treatment consists in early multiple incisions into the infiltrated tissue.

Complications of Inflammation.—Aside from the possibility of pus dissecting into the mediastinum, producing purulent mediastinitis, pericarditis, pleuritis, and abscesses of the lung, it may break through into neighboring organs, such as the trachea, the œsophagus, and in rare cases into the large vessels. Perforation of the large vessels is particularly grave, and is caused by necrosis of the wall due to extension of the inflammation or because the vessels have been eroded by the surrounding pus. The danger is the subsequent hemorrhage and possible entrance of pus into the circulatory system. Hemorrhages due to abscess are observed in severe types of suppuration, especially in children after scarlet fever. The arteries are most frequently involved, because the veins are apt to become filled with a thrombus or obliterated before the lumen is opened. This complication has been reported in connection with almost all the arteries of the neck. According to the statistics of Gross, the common carotid was affected 5 times, the internal carotid 3 times, the subclavian, the superior thyroid, the inferior thyroid, and the lingual once each. The internal jugular vein communicated with the abscess in 12 cases. Perforation frequently takes place the moment the abscess is incised or shortly before. The arterial hemorrhage is oftentimes so profuse that death follows quickly. When less pronounced, it may recur at intervals. Bleeding following erosion is always dangerous to life, although ligation has several times been followed by recovery. Dolbeau tied the external carotid with success in a young girl on account of hemorrhage from an eroded lingual artery, and Socin tied the common carotid for hemorrhage from the external carotid.

Chronic Inflammatory Processes of the Neck.

Tuberculosis and actinomycosis are the principal diseases giving rise to chronic inflammatory processes and cold abscesses.

Tuberculous Abscesses.—In the vast majority of cases tuberculous abscesses arise from the lymph-glands. Only a small percentage of abscesses are the result of infiltration from neighboring foci in bones and joints, such as the spinal column, the mastoid process, or the lower jaw and sternum. The former will be considered in connection with tuberculosis of the lymph-glands, and the latter with inflammation of the corresponding bones.

Actinomycosis.—Next to the jaw and the cheek, the neck is most frequently affected by this disease. Of 100 cases observed in Bergmann's clinic (Schlange), 45 were of the jaw and 35 of the neck. Of 34 cases reported by Albert (Illich), 28 were of the head and neck; and in 25 cases in the author's clinic (Frey) the neck alone was affected 13 times. It may not always be possible to separate actinomycosis of the neck and of the head sharply from each other, because in many cases the process begins in the region of the jaw and spreads thence to the neck. The fungus usually finds entrance through carious teeth. Israel and Partsch demonstrated pure cultures in the cavities of teeth. Wounds of the mucous membrane, ulcers of the gum, and the tonsil may be the portal of entrance. The primary focus develops in the vicinity of the lower jaw, and from this extension takes place by direct infection of the tissues without necessarily invading the lymphatic system. A diffuse, slowly increasing painless swelling develops in the submental and submaxillary region or in the vicinity of the angle of the jaw. This indurated area gradually breaks down in the centre while the circumference remains hard and brawny. The skin over the swelling is livid, and becomes thinner at the apex of the swelling and finally breaks, allowing a slight amount of sticky or tenacious purulent fluid to escape. Flabby granulations mottled with yellowish spots, which contain the characteristic fungus, spring up around the opening of the sinus. In the meantime the infiltration has extended to the neighboring parts, and softening takes place again with renewed infiltration at the circumference. Pseudofluctuating areas alternate with brawny places, a condition characteristic of actinomycosis. If the condition is not treated, the infection extends along the sternomastoid to the clavicle and from one side of the neck to the other. When the fungus has reached the lower half of the neck, the primary focus may have already healed. Dense connective-tissue strands leading up to the lower jaw usually indicate the seat of the primary infection. The more chronic the process, the greater the development of connective tissue. Tumors the size of a fist, which have many sinuses, gradually develop. In a process that is so extensive there are always a number of associated disturbances, such as limitation of movements of the head, difficulty in swallowing, and dyspnœa even to suffocation.

As a rule, actinomycosis has a tendency to spread superficially and to rupture externally. Only rarely does the fungus penetrate below the cervical fascia and reach the large vessels. In the loose connective-tissue sheath the process may rapidly extend to the mediastinum, the pleura, or to the lung and heart. Extension of the process to the internal jugular vein may be followed by rupture into the circulatory system, thus producing general infection. In a case observed by Ponfick and Schlange, general actinomycotic pyæmia could be traced to an infected thrombus of the above-named vein. When the process extends upward along the ascending ramus of the jaw to the vertebral canal, to the base of the skull, and to the brain, a fatal result is to be expected. The local suppuration leads to disturbances of the general condition only when existing for a considerable length of time. After many years cachexia and amyloid degeneration of the abdominal viscera may become evident.

A purely actinomycotic infection is essentially chronic. Aside from this typical form, there are cases in which the course is acute or subacute, in which the amount of connective tissue formed is less, and in which suppuration is so marked that the clinical picture is one of acute purulent inflammation. This atypical course is produced by mixed infection with pyogenic cocci that reached the seat of disease in the same way as did the fungi.

Roser described as actinomycosis 3 cases of severe suppuration in the submaxillary region, with symptoms of angina Ludwigii and foul pus containing fungi. Capper reports a similar case in a soldier twenty-two years of age, in whom suppuration developed on the right side and then in the left submaxillary region. The characteristic organisms were found not only in the pus, but also in two carious lower molars. In all 3 cases incision was followed by rapid recovery. The milder, acute or subacute cases are much more frequent than the fulminating cases, resembling ordinary alveolar abscesses, the true character of which is discovered after operating. An acute onset of the disease is not infrequently followed by a chronic course.

Diagnosis.—The diagnosis depends on finding the ray fungi in the secretion or in the granulations. This can only be done after opening the focus. A probable diagnosis can in most cases be made clinically. The pseudofluctuating consistence, the dense infiltration of the tissue, the absence of sharp outlines, and, above all, the peculiar bluish discoloration of the skin over the soft areas, are more or less characteristic. The differential diagnosis will first of all consider tuberculosis of glands associated with periadenitis. Against this would be the absence of an abscess, the large area involved with a relatively small tumor, and the absence of glandular enlargement in the vicinity. This is hardly ever absent even with isolated tuberculous glands. Actinomycosis may further be confounded with malignant tumors, especially in old people. Early softening and changes in the skin, the varying consistence of different portions of the swelling, the absence of glandular infection in the vicinity, and finally the absence of a sharp outline even in the early stages will, as a rule, exclude sarcoma and carcinoma. The differentiation from tertiary syphilis may be somewhat more difficult inasmuch as treatment with potassium iodide does not always give conclusive evidence.

If the disease is well advanced, and if there are ulcerations of the skin and sinuses, it is possible to determine accurately the nature of the affection by microscopical examination of the pus or of scraped-off masses of granulation-tissue.

Prognosis.—Extensive clinical experience during the last few years has shown that the tendency has been to be too pessimistic as regards the prognosis. The disease has without doubt a tendency to spontaneous cure, and it frequently happens that recovery takes place without the nature of the disturbance being recognized. The chief danger is extension of the process to the deep-seated structures of the neck. This may be avoided, as a rule, by prompt interference. With the present methods of treatment cure follows in the great majority of cases of actinomycosis of the neck. The sooner the diagnosis is made, the better the chances of recovery. This statement is supported by Schlange's publication, according to which all of the 35 cases of actinomycosis of the neck reported in Bergmann's clinic were cured.

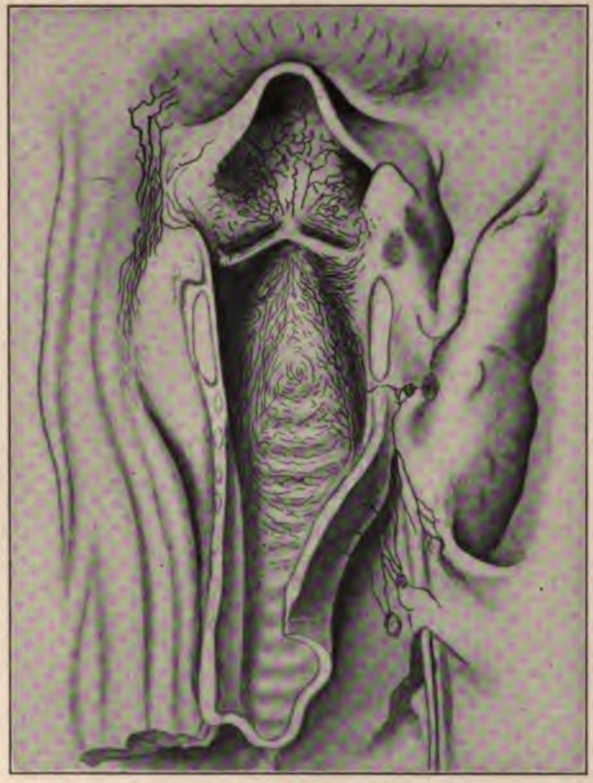
Treatment.—Simpler methods of treatment have gone hand-in-hand with improvement in the prognosis. Mutilating operations, the free use of a cautery or of chemical corrosives, has been rendered unnecessary. It is quite sufficient to open the focus by a simple incision, remove the soft tissue with a sharp spoon, and subsequently pack the cavity and passages with iodoform gauze. Potassium iodide has been shown to be a valuable aid to operative treatment, and was introduced into practice on account of its effect in animals, demonstrated by Van Iterson. Experience shows that potassium iodide alone will at times cure superficial foci of actinomycosis. According to Prutz, 9 cases of actinomycosis of the jaw and neck were completely cured out of 13 treated exclusively by the iodide. The other 4 improved (still under treatment). The action of the iodide is more certain if the focus has been opened by an incision. This combined treatment in 28 cases was followed by complete recovery and by improvement in 11 out of 17 cases treated (jaw and neck).

According to the investigations of Jurinka and Prutz, potassium iodide is not a specific in the sense that it destroys the vitality of the fungus. It influences the tissues so that the foci are more sharply localized and pushed toward the surface. This action is not observed in every case, but is seen in the majority of cases. For the purpose of rendering operative interference simpler and more easy, it is advisable when the disease is at all extensive to administer potassium iodide as a preliminary measure and continue after operation. Rydygier has recommended the use of potassium iodide locally, besides administering the drug internally in a watery solution in doses of 15 grains or more. A [illegible] solution of the iodide is injected into various parts of the [illegible] repeated daily or [illegible] mycosis of the [illegible] istration of [illegible] recovery [illegible] ally favorable [illegible] size of a [illegible] sinuses. [illegible] Lugol's solution [illegible] advanced cases, the [illegible] combined treatment [illegible]

DISEASES OF THE LYMPH-GLANDS OF THE NECK.

Acute Lymphadenitis.—Acute lymphadenitis is common in the neck, and follows either an acute inflammatory process in the region drained by the particular glands or arises to all appearances spontaneously. In the latter case the peripheral inflammation has already subsided or is so slight as to be insignificant, or the producers of infection have reached the glands directly through some unknown point of entrance. Oval or round smooth nodes very sensitive to pressure develop. They are often so soft that they seem to fluctuate. They diminish in size in a few days. In other cases suppuration takes place and the abscess breaks externally. Inflammation appears either in a gland previously healthy or in a gland already tuberculous.

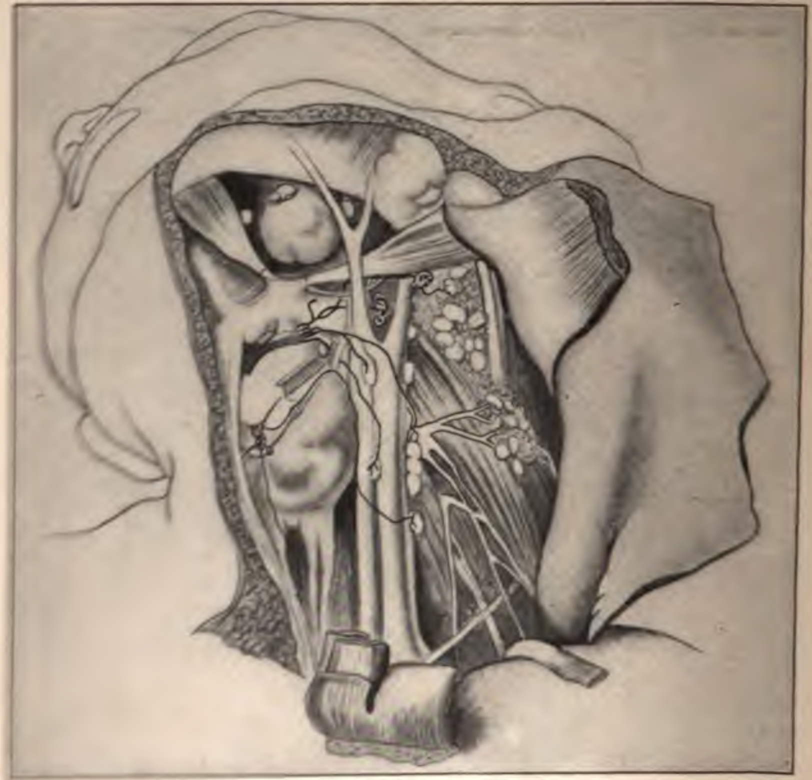
FIG. 26.



Lymphatics of pharynx and trachea.

Chronic Lymphadenitis.—**Simple Hyperplastic Lymphoma.**—This term includes those lymph-nodes that do not enlarge beyond the size of a hazelnut or walnut. This enlargement is produced by chemical or bacterial irritants entering by way of the lymphatic vessels from the periphery. The enlarged gland may undergo no change for years, and show no tendency to suppurate or form adhesions. There exists hyperplasia of all the glandular elements. In some cases hyperplasia of the cells predominates. These increase in size and appear epithelioid (large-cell hyperplasia). In other cases the formation of new connective tissue predominates, and the cells are compressed or destroyed by the overgrowth of fibrous tissue (fibrous hyperplasia). In the first type the enlarged gland is soft; in the latter it is hard.

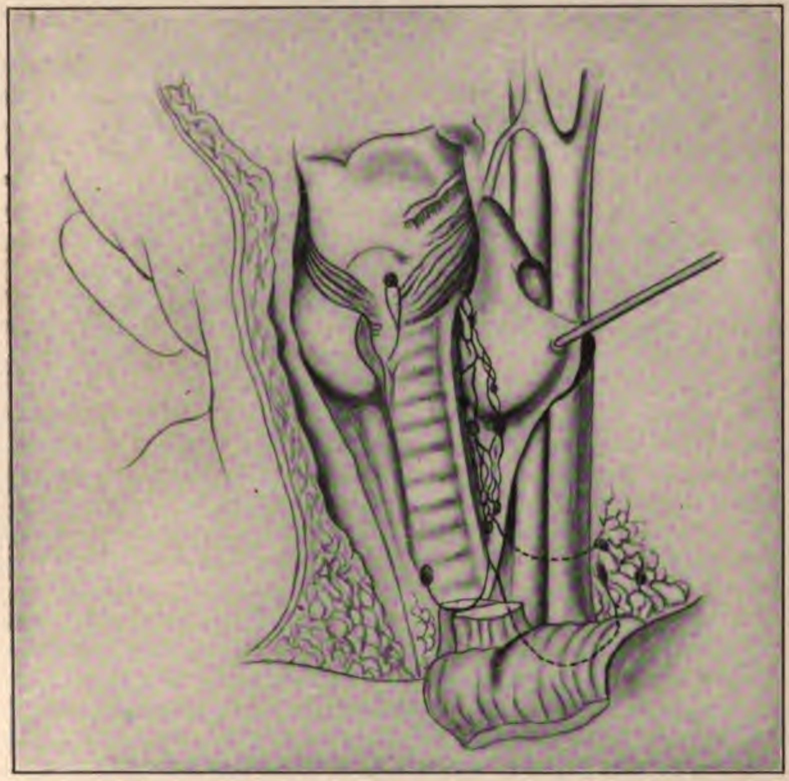
FIG. 27.



Showing lymphatics of pharynx and trachea.

The most common cause of hyperplastic lymphoma is acute inflammatory irritation. It may, however, develop quite slowly without appreciable inflammation. Prolonged irritation in the regions drained by the lymphatics leading to the gland usually explains this condition. Any acute inflammation of the head or neck, such as boils, carbuncles, suppuration, alveolar abscesses, sore throat, infected wounds, etc., as a rule, give rise to acute lymphadenitis in the neck that subsides usually after the primary focus is removed. It may, however, persist and the glands remain permanently enlarged. Chronic inflammation of the skin and mucous membrane, eczema, pharyngeal and nasal catarrh, chronic blepharitis, hypertrophy of the tonsils, ulcers of the gums, all play an important part in the etiology of chronic hyperplasia of lymph-glands. Caries of teeth is also a common factor, because of the numerous bacteria frequently contained in the cavity. A chronic state of irritation in the gland is produced by the bacteria or their toxins reaching the glands through the dentine canals and the lymphatics. Odenthal's and Stark's investigations have proved beyond doubt the connection between hyperplastic lymphoma of the neck and caries of the teeth. In only 20 per cent. of the children who had enlarged glands of the neck was caries of the teeth absent, and in these there was a history of tuberculosis, previous diphtheria, or sore throat. Of the 80 per cent. with caries of the teeth, 16.8 per cent. had a tuberculous family history, 22.2 per cent. showed other etiological factors (tuberculosis, previous infectious diseases), and in the remaining 41 per cent. only the carious teeth could be found to account for the enlarged glands. The situation and number of enlarged glands

FIG. 28.



Showing lymphatics of pharynx and trachea.

corresponded accurately to the teeth affected. The average age of the children was eight and a half years. Simple hyperplastic lymphoma may appear at any time of life, but the majority of cases occur in childhood, especially in the first decade, for the reason that primary disease of the regions drained by the lymphatics is very common in children. After the tenth year the tendency to inflammation of the skin and mucous membrane progressively diminishes. Acute infectious diseases (scarlet fever, measles, diphtheria) become less common, and the glands lose their extreme sensitiveness to inflammatory irritation. Vollandt's and Laser's investigations in schools have shown that the majority of children are affected with glandular enlargement of some sort, and that the percentage of lymphoma diminishes progressively with successive years.

Laser found only 137 out of 1216 children in several schools—*i. e.*, 11.3 per cent.—without glandular enlargement. The swelling of the glands in the vast majority of the cases could be traced to various infectious diseases: 79 per cent. of the cases had had measles; 35.7 per cent., scarlet fever; 21.9 per cent., inflammation of the tonsils; 18.8 per cent., diphtheria; and a few, tuberculosis. Vollandt examined 2506 children, and found that enlargement of the glands was present in 96 per cent. of the children between seven and nine years, in 91 per cent. between ten and twelve years, in 84 per cent. between thirteen and fifteen years, in 69.7 per cent. between sixteen and eighteen years, and in 68.3 per cent. between nineteen and twenty-four years.

Hyperplastic lymph-glands are usually small, the size of a bean or hazelnut, rarely as large as a walnut, movable, not sensitive to touch, sometimes soft, sometimes hard, but usually of medium consistency, and cause no annoyance to the individual. They may be single or multiple, unilateral or bilateral, and the area involved depends directly on the seat of the peripheral focus. After the primary cause subsides they usually disappear, undergo fibrous contraction, and become small and hard.

PROGNOSIS.—The prognosis is favorable. Hyperplastic lymphoma is generally harmless, and annoys only from a cosmetic standpoint. Complications are only possible when secondary infection takes place. The invasion of pyogenic cocci may lead to acute suppuration of the gland, and tubercle bacilli may produce tuberculous lymphoma. The hyperplastic gland tissue is a favorable medium for these organisms.

DIAGNOSIS.—A positive diagnosis, as will be seen, can only be made by microscopical or bacteriological examination of the enlarged glands, for the initial stage of glandular tuberculosis does not differ clinically from that of simple hyperplastic enlargement.

TREATMENT.—If the glands remain stationary for a long time, and diminish in size after subsidence of irritation in the region drained by the afferent lymphatics, the enlargement is probably benign. If, on the other hand, the gland increases in size after the peripheral infection has subsided, and especially if softening occurs with adhesions to the surrounding tissues, then tuberculosis is to be suspected. For instance, if a child comes for treatment with movable glands in the upper triangle of the neck and considerable hypertrophy of the tonsils, one should, first of all, excise the tonsil. If the lymph-glands do not diminish in size in the course of a few weeks, it is reasonable to suspect tuberculous inflammation of the gland, provided no other etiological factors can be found. Excision is then justifiable. In spite of the benign character of hyperplastic glands they should always be treated, especially in children of tuberculous parents and those in contact with tuberculous adults. In cases of this sort the chances of becoming secondarily infected with tuberculosis are great. The chief indications in treatment are to remove the eczema, catarrh, and carious teeth, and to excise hypertrophied tonsils. The only indication for excision of the gland is suspicion of tuberculosis. In doubtful cases a gland may be excised for the purpose of diagnosis. Painting with tincture of iodine, poultices, etc., are the means usually adopted in practice when an attempt is made to remove hyperplastic glands without operation.

Scrofulous Lymphoma.—This condition does not exist pathologically, and, strictly speaking, the term scrofulous gland should no longer be used. The changes in glands that were formerly called scrofulous are in part simple hyperplasia, in part tuberculosis. One might still speak of a scrofulous diathesis, meaning that anomaly of constitution in childhood manifested by a tendency to chronic non-specific inflammation of the skin and mucous membranes with secondary enlargement of the glands of the neck. When nodules, caseation, and adhesions are present, the surgeon has to deal with the results of tuberculous infection. As far as the glands are concerned, the term scrofula is applied in this connection to simple hyperplasia.

There is not as yet any differential diagnostic criterion of the initial stage of glandular tuberculosis. The surgeon is not able clinically to define accurately where simple hyperplasia ceases and tuberculosis begins, for it is not possible to determine whether there are bacilli or nodules or small foci of caseation present. It is at times impossible to decide macroscopically or microscopically whether tuberculosis is present or not. The use of the word scrofula should be restricted to those uncertain cases of glandular enlargement that form the border cases. As far as the relation of scrofula to tuberculosis is concerned, the chronic simple hyperplasia of the gland due to the scrofulous diathesis furnishes the medium upon which tuberculosis develops. The changes of tissue are present that enable the bacilli to grow. There is a predisposition of the gland to tuberculosis. Scrofula, therefore, may be a preliminary stage of gland tuberculosis. The majority of children have scrofulous lymphoma, but only a small percentage acquire tuberculosis. The change from simple hyperplasia to tuberculosis is, as a rule, very gradual and not recognized, and as the course is not diagnostic, inasmuch as tuberculous glands may at times diminish in size, no definite relation can be expressed in numbers between the frequency of simple and tuberculous lymphoma.

Tuberculous Lymphoma. Since the discovery of the bacillus of tuberculosis the field of glandular tuberculosis has been widened. There are, as already mentioned, a number of glandular conditions that were formerly considered to be simple swelling or scrofula which are really tuberculosis. The changes in a gland produced by a bacillus are manifold, and the anatomical and clinical picture of the disease vary correspondingly, which makes it necessary to distinguish several types.

1. *The Purely Hyperplastic Type.*—As is shown by the descriptions of several accurately observed cases (pseudoleukæmic form), it may happen that the bacilli produce simple hyperplasia of the gland without the formation of tubercles. This variety of lymphoma does not differ macroscopically nor microscopically from simple hyperplastic or malignant enlargement, and its nature can only be determined by demonstrating the bacillus. These bacteria are present in the glandular tissues as a rule in very small numbers, so that an accurate diagnosis can only be made by animal inoculation. As yet no extensive histological investigations have been made on this subject.

2. *Hyperplasia with Tubercles.*—The pale-gray or grayish-red transverse section of an enlarged gland shows even to the naked eye fine prominences or dull-gray points that prove microscopically to be typical tubercles. These develop in the follicular tissue, gradually infiltrate this, and become confluent, forming larger nodules which soon begin to show degenerative changes. The number of bacilli present is usually small, and they may even escape detection. The size of a lymph-gland containing tubercles may vary considerably. Some are no larger than a pea, others are as large as a walnut or an egg. These differences are explained by the varying intensity of the reaction following infection as well as by the previous history, which would in all probability show that some of the glands had previously been enlarged. At any rate, it is a fact that in the same group of glands very large and very small lymphomata are to be found, all showing the same pathological changes.

3. *Caseation.*—Enlargement of a tubercle is associated with process of degeneration, giving rise to caseation. Single or multiple foci of caseation varying in size appear in the tissue of a gland. Some are scarcely as large as the head of a pin. On the other hand, the entire gland may be changed to a uniform caseous mass. The consistence of this caseous material varies. At times it is so hard that a section of the gland presents a gummatous appearance. At times it is soft or even fluid. Liquefaction leads to the formation of abscesses with pus-[illegible] fluid. [illegible] contents consisting of degenerated cells and detritus. Caseation [illegible] place in hyperplastic as well as in the smallest glands without [illegible] so that a hyperplastic stage need not necessarily precede [illegible]

[illegible]ndary *Conditions due to Extension of Inflammation to the Cap-[illegible]roundings.*—If caseation progresses toward the periphery, [illegible] gland becomes secondarily inflamed. It will be [illegible] connective tissue, is brawny, and adheres to the surrounding glands, skin, vessels, muscles, etc. The thickened capsule and the surrounding fibrous tissue oftentimes form a barrier to the advance of intracapsular abscesses. This fibrous covering is, however, finally perforated, and the tuberculous pus pours out into the surrounding tissues and reaches the surface directly or in a roundabout way. Subcutaneous abscesses, fistulæ, and ulcerations develop in this way. The several stages of tuberculous inflammation may be combined in a variety of ways. Glands of the same group may be hyperplastic with tubercles, while others show abscesses and small foci of caseation.

Mixed infection with pyogenic cocci is rather common. This gives rise to acute suppuration and periadenitic inflammation. The origin of such abscesses is oftentimes recognized at the operation for the first time by the admixture of caseated gland remnants with the pus. Suppuration of this sort may obliterate all the tuberculous gland-tissue, and spontaneous recovery may follow. If the pyogenic infection is primary in the periadenitic tissue, the entire lymphoma may form a sequestrum, as it were. Recovery may be permanent after this has been thrown off. Glandular tuberculosis may resolve at any stage. In hyperplastic glands fibrous contraction may cause disappearance of the tubercles, while foci of caseation become encapsulated and rendered inert by overgrowth of connective tissue. Finally, the focus may become covered with a crust of calcium salts that sometimes remains unchanged for years. Not infrequently secondary infection gives rise to fresh inflammation, rupture of the gland, and sinuses. In operating upon such fistulæ one is often surprised to find a concretion at the bottom of the sinus. Calcification of caseous glands is most frequently observed in older people. Abscesses may empty externally with subsequent recovery, provided the entire gland-tissue has become necrotic. The length of time that a sinus persists depends upon the amount of tuberculous gland-tissue left behind.

ETIOLOGY.—Formerly glandular tuberculosis of the neck was supposed to be an expression of general glandular infection. Of late more accurate knowledge of the sources of infection has demonstrated that this disease in the majority of cases is a local process, and that the tuberculous virus reaches the glands through the lymphatic vessels. The more the sources of infection were understood, the greater the field of secondary tuberculosis, with which practical surgery is chiefly occupied. The invasion of bacilli may take place from the periphery or from some central focus (bronchial glands). The ascending form, however, is probably far more uncommon than the descending. The bacilli entering at some peripheral point need not cause specific changes at the seat of entrance, so that the glandular infection seems to be primary (secondary glandular tuberculosis without evident primary focus). Secondary tuberculosis with evident primary focus is a rarer observation, and is noted in connection with disease of the skin and mucous membrane of the head (lupus, tuberculous ulcerations of the tongue or gums).

Cornet has demonstrated by experiments on animals that tubercle bacilli may penetrate the intact mucous membrane and cause glandular tuberculosis. It is, however, not known whether this method of infection takes place in man or not. It does not seem improbable that skin and mucous membrane deprived of its protecting epithelium may serve as a point of entrance for infection. The same diseases that give rise to simple chronic glandular enlargement in children are also made responsible for glandular tuberculosis (eczema, catarrh, ulcerations of the gums). Caries of the teeth is also of great importance etiologically. Tubercle bacilli are almost always present in the cavities of teeth in consumptives, and have even been found in those of healthy individuals. The connection between tuberculosis of the glands and bacilli entering by way of the teeth was first demonstrated by Ungar, and subsequently by Stark. Caries of the teeth is extremely common in children, so that this source of infection is of great importance. The tonsils form a further nidus of infection; their importance in this direction has been demonstrated by Baumgarten, Hanau, Schlenker, and Krückmann. The anatomical structure of the tonsil predisposes to the entrance of bacilli, for the epithelium is always porous owing to the perpetual transmigration of leucocytes, and may even be absent over small areas. Microbes usually invade the tonsil through the crypts that are well known as hiding-places and breeding-spots. The enlargement of the organ and irregular surface in chronic hypertrophy favor infection. The resistance of the tissue under these conditions is diminished by the primary catarrh and the loosening and throwing off of epithelium.

Dieulafoy injected guinea-pigs with bits of hypertrophied tonsils and produced tuberculosis in 8 cases out of 61. Although these results are not beyond criticism on account of the absence of histological investigation, showing primary tuberculosis in the tonsil, yet it is demonstrated beyond doubt that bacilli were present in the pieces of tissue that were injected into the pigs. Previous to this Orth showed that tubercle bacilli might be present in the tonsils of children that had died of diphtheria. Baumgarten succeeded in producing tuberculosis of the tonsils and of the glands of the neck in animals by feeding tuberculous material to them; and Dmoschowsky in his investigations found the bacilli in the adjoining lymphatic vessels. Autopsies performed by Strassmann, Schlenker, and Krückmann, showed the frequency of tuberculosis of the tonsils in consumptives and almost constant tuberculous changes in the tonsils when tuberculosis of the glands of the neck was present. Ruge found numerous tubercles in the enlarged tonsils of a girl eighteen years of age, and pronounced the affection primary, considering the caries of the cervical vertebræ present at the same time to be secondary. In 18 cases of hypertrophied tonsils removed mostly intravitam, he found definite tuberculous changes 6 times. Steward found numerous tubercles and giant cells in the tonsils of a child with enlargement of the glands after scarlet fever. After excision these were shown to be tuberculous.

Entrance of bacilli in itself may be sufficient to produce tuberculous inflammation of the glands, as borne out by the fact that tuberculosis is observed in individuals previously healthy with no hereditary taint. The number of bacilli and their virulence must, of course, be great to cause healthy gland-tissue to succumb. In the majority of cases tuberculosis is dependent on predisposition of the glands to this specific infection. This predisposition may be general or due to local causes. The general causes are hereditary taint, the presence of tuberculosis elsewhere, diminution of resistance due to previous acute infectious diseases, and faulty hygienic surroundings. The local causes are previous inflammatory changes in the glands, especially simple chronic hyperplasia.

A tuberculous taint can be proved to exist in about a third of the cases. In the author's clinic it was present in 101 of 308 patients (32 per cent.), and Blos, who analyzed the material very carefully, showed the percentage in other statistics to vary between 14 and 38, thus giving an average of 28 per cent. Tuberculosis of other organs is found rather frequently in patients with glandular involvement. Of 160 patients observed very closely in the author's clinic, 26 per cent. showed changes in the lungs, and 14 per cent. tuberculous foci elsewhere. Of 114 patients in Billroth's clinic (Fränkel), 10 per cent. showed pulmonary tuberculosis. It is a well-known fact that tuberculosis of the glands may develop quite quickly in children after acute exanthemata. These predispose to tuberculosis by giving rise to enlargement of the glands in the neck, and by diminishing the general resistance.

The glands in the neck are those affected most frequently by far in lymphatic tuberculosis: about 90 per cent. of the cases (82.2 per cent., according to Guiseppi Berruti; 93 per cent., Wohlgemuth; 95 per cent., Riedel; 89 per cent., Blos, Heidelberg clinic). This prevalence is explained by the fact that the region drained by the lymphatic vessels is especially exposed to infection with bacilli (head, face, mouth), and the glands themselves are, as has been mentioned, enlarged in the vast majority of children.

Glandular tuberculosis may develop at any age. The tendency to infection varies with the times of life, as is shown by the accompanying statistics. Fürnrohr prepared the following table from 126 cases:

First decade	9.5	per cent.
Second "	31.7	"
Third "	44.4[1]	"
Fourth "	7.9	"
Fifth "	4.0	"
Sixth "	0.7	"
Seventh "	1.6	"

Almost identical percentages are observed in the author's clinic. Of the 308 cases operated upon, 215—*i. e.*, 70 per cent.—were between ten and twenty-five years of age. Fränkel mentions that tuberculous lymphoma occurs most frequently between the fifteenth and thirtieth year of life. Whereas simple hyperplastic swelling of the glands diminishes rapidly in frequency after the first decade, tuberculous lymphoma increases from the time of puberty and reaches a maximum between the fifteenth and thirtieth year. This fact is strange, because in childhood the opportunities of becoming infected with the bacilli are very numerous (intimate association of the children with adults and frequent contact with the dirt of the floor, etc.). Hyperplastic glands are presumably already infected with tubercle bacilli, but the changes taking place at puberty, as well as the changes for the worse at this time regarding food and living among the poorer classes (change from schools to workshops and overtaxing the strength by physical work), prepare the soil for ravages of the bacilli, and are responsible for the increase of tuberculous lesions. Sufficient histological examinations of simple hyperplastic glands in the first decade of life are not at hand to decide definitely this question.

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[1] 76.1 per cent. in the second and third decades.

Both sexes are about equally attacked by tuberculosis of the glands of the neck.

Social differences play an important part. The vast majority of the cases are of the poorer classes. In those whose station in life is more favorable the disease is relatively uncommon, and when present it appears only in a very mild form.

SYMPTOMS.—The clinical picture varies greatly. There may be a movable glandular enlargement of the submaxillary region the size of a nut or there may be numerous sinuses and ulcers of the skin on both sides of the neck leading down to a mass of glands the size of a fist. These differences are only quantitative. The presence of periadenitis—i. e., of periglandular processes—has considerable influence on the clinical conditions. These changes are of paramount importance for diagnosis, prognosis, and treatment. The clinical subdivision is based upon their presence or absence, thus cases in which the process remains intracapsular and in which the capsule is perforated.

1. *Lymphoma without Periadenitis.*—In this group the differences in clinical picture depend on the extent of the disease.

(a) A solitary gland becomes infected with tuberculosis and gradually reaches the size of a nut or even that of an egg. The tumor is [illegible] soft consistency, has a smooth surface, is [illegible] on the underlying tissues, and is not [illegible] the main tumor, careful palpation will [illegible] nodes in the vicinity, and on [illegible] glands will be found near the chief [illegible] the same conditions. In the [illegible] disease of all members [illegible] more noticeable on account [illegible] larged glands are found most [illegible] regions, in front of and [illegible] fossa and other regions [illegible] people, and may be diffi[illegible] from other conditions.

More frequently the glands belonging to one group are all involved at the same time. They unite to form a movable tumor which can easily be shown to consist of individual nodes that vary in size and consistency. The shape of the tumor depends upon the mutual arrangement of the individual glands in the group.

Disease of an individual group of glands may extend to neighboring groups, and finally involve all the glands of one side of the neck. The size of the tumor increases correspondingly, so that the neck may be surrounded by large nodular tumor masses.

Glandular disease is frequently bilateral. The intensity of the tuberculous process varies in the individual glands. Glands of the same group may show on section hyperplasia without caseation, or multiple foci of caseation or abscesses. On the other hand, all the glands of one-half of the neck may present identical pathological changes. Hyperplasia pure and simple is rather uncommon. It was present in only 16 of 308 cases observed in the author's clinic. As a rule the cut section shows foci of caseation of varying size, either isolated or multiple. Small abscesses usually develop in the interior and spread toward the periphery, so that finally nearly the whole of the gland is changed into an abscess surrounded only by a dense layer of gland-tissue. Such abscesses without periadenitic changes may be found in isolated lymph-nodes as well as in the interior of tumors made up of a number of glands.

The clinical diagnosis of intracapsular changes is oftentimes difficult, because the hyperplastic lymphoma may be so soft as to resemble a fluctuating mass; and again the central abscess may have so thick a wall that it is difficult or even impossible to detect fluctuation. One is oftentimes misled as to the extent of the disease because only the more superficial glands can be felt. As the individual groups of glands in the neck are closely connected, especially the superficial and deeper ones, the process as a rule is much more extensive than one would suspect from the apparent size of the tumor.

The course of the disease is essentially chronic, but is subject to considerable variation. There are cases in which individual glands remain unchanged for many years. On the other hand, there are such in which the disease attacks all the glands on both sides of the neck within a short space of time and leads to the formation of extensive tumors. Besides the benign variety, there is a very malignant type that rapidly terminates fatally with the clinical signs of pseudoleukæmia.

The characteristics of this pseudoleukæmic type are the absence of periadenitic changes and the absence of caseation, at least in those cases reported by Baumgarten. Macroscopically the diagnosis is impossible. In case of doubt one should always excise a gland for microscopical or bacteriological examination because in those cases at least that are not quite so fulminating recovery may follow excision of the tuberculous material.

In cases without periadenitis the tuberculous glands may resolve or increase and degenerate.

2. *Lymphoma associated with Periglandular Processes.*—When caseation advances toward the periphery, the capsule of the gland becomes inflamed. This gives rise to fibrous thickening and agglutination of the gland to neighboring ones and surrounding organs. The mass of glands becomes fixed by these adhesions and fibrous tissue, so that the individual glands composing the mass are no longer to be distinguished. The new connective tissue formed may be so abundant that the tumor has a solid, even bony consistence, which at times in older people may give rise to errors in diagnosis. The tumor is mistaken for a carcinoma or even for new bony formations (cervical rib). When caseation and softening occur in the gland, the thickened capsule is finally perforated and the pus diffuses into the surrounding parts. At this stage the gland is usually closely adherent to the skin provided one of the superficial group is involved. This becomes œdematous and discolored, is lifted off by the pus from the subcutaneous tissue, appears more or less elevated, becomes thinner from the inside out, and finally breaks. The abscess empties itself externally and a sinus with undermined edges remains which leads to a cavity. When this condition continues for any length of time, extensive ulceration of the skin will be found and fungiform masses of granulation-tissue present at the opening of the sinuses. Deeper seated suppurating glands usually rupture into the periglandular tissue and the pus burrows between the individual glands. If it reaches the connective-tissue sheaths of the large vessels and muscles, it may descend and come to the surface just above the clavicle, in the suprasternal region, or even on the anterior surface of the chest. Long, tortuous sinuses are produced leading to the primary focus.

Purulent periadenitis may occur in an individual gland or it may take place in large groups of glands. Secondary infection with pyogenic cocci undoubtedly gives rise very frequently to this condition, as shown by the fact that it appears usually with symptoms of acute inflammation. The acute onset is, as rule, followed by a chronic course; improvement and retrogressive changes alternate. While the sinus closes in one place and ulcers show a tendency to heal, abscesses, new sinuses, and ulcers are formed in other places. In severe cases of glandular tuberculosis the entire neck may be covered with sinuses and spongy granulations that are connected with underlying nodular tumors. Although mixed infection with pyogenic organisms may sometimes be productive of destructive changes, it may have a beneficial effect by producing acute purulent softening and elimination of the tuberculous tissue. A cure of this sort, however, is only possible when the enlarged glands are quite superficial. Where there are tortuous sinuses extending along the large vessels and the vertebral column it is conceivable that the extensive tuberculous mass can be thrown off only in the course of many years. Suppuration from a sinus extends frequently over long periods. The scars seen after spontaneous cure are characteristic and indicate their origin. They are never linear or smooth, but always irregular, broad, and spread laterally—ray-like—elevations and depressions alternate, and they are adherent to the underlying tissues. They may be thin or very thick, and not infrequently are covered with bridge-like bands. Any group of glands may be primarily affected and form the seat of origin of extensive tumors. In the majority of cases, however, the extension is from above downward, the glands of the upper half being first affected, and later on those of the lower half. Extension rarely takes place upward—*i. e.*, from glands of the lower triangle of the neck to the upper ones. Several groups may be diseased at the same time.

Glandular tuberculosis usually exerts no influence whatsoever on the general condition. In only 11 per cent. of the author's cases were there general constitutional disturbances, such as loss of appetite, etc. In non-complicated cases fever is not present as a rule. In the pseudoleukæmic type the temperature may rise to 40° C. If fever is present for reasons other than this, the cause is usually some suppurative process produced by mixed infections, or coincident tuberculous disease of other organs, especially the lungs. Generally speaking, absence of pain is characteristic of tuberculous lymphoma. The pain occurring in rare cases is produced either by acute inflammatory processes, pressure, or adhesions affecting the nerves. In the latter case the pain is usually neuralgic. Neuralgia of this sort is apt to be caused by small masses of glands, thus making the diagnosis more difficult (confounded with malignant tumors).

In spite of the enormous size of some glandular tumors pressure-symptoms referable to neighboring organs are observed in but few cases (œsophagus and trachea). In one of the author's cases there were dyspnœa and difficulty in speaking; both of these symptoms disappeared after excision of an adherent mass of glands on the right side. Statistics show that a certain percentage of patients suffering from tuberculous glands of the neck have tuberculosis of the lungs, and succumb to this complication; 26 per cent. of 160 carefully observed cases in the author's clinic had changes in the lungs. In Fränkel's statistics the percentage of mortality was 10.2; in Fürnrohr's, 26.4; in Wohlgemuth's, 12; in Demme's, 21. Van Noorden calculated from the material of v. Bruns' clinic that 20 per cent. of the patients with tuberculous lymphoma succumbed to tuberculosis of internal viscera.

Diagnosis.—A diagnosis is generally easy in those cases of glandular tuberculosis associated with abscesses and sinuses. The condition may be confounded with actinomycosis, and very rarely with gummatous changes in the lymph-glands. In doubtful cases the detection of the characteristic ray fungi in the pus will dispel the uncertainty, and in syphilis the results of treatment with potassium iodide will settle the question. In older people, ulcerating malignant tumors, especially lymphosarcoma, may have to be considered in the differential diagnosis. The irregular contour of tuberculous tumors, the nodules of differing consistence, the characteristic appearance of the skin, ulcers, and the fungiform masses of granulation will enable a correct opinion clinically, which may be supported by microscopical examination of portions of the tumors.

Diagnostic difficulties are met more frequently in cases without periadenitis, as well as in cases in which the pericapsular fibrous tissue is very extensive. In childhood tuberculous lymphoma may be confounded with simple chronic glandular swelling. In favor of tuberculosis would be the size, the steady increase, the persistence of the nodules after recovery from any peripheral affection that may have been present, and finally a tuberculous taint or the presence of tuberculous lesions elsewhere. In doubtful cases microscopical examination of an excised gland alone will enable a diagnosis. In the second and third decades pseudoleukæmia must be taken into consideration, especially in the early stages of the disease. An absolute diagnosis may not be possible in these cases, but a probable diagnosis in favor of malignant lymphoma can be made when enlargement of the glands begins in a previously healthy individual not tainted hereditarily and showing no peripheral affection bearing any relation to tuberculosis. Vicious progress and extension to the glands of the entire neck and to those of the rest of the body, the uniform consistence of all the nodes, the presence of pressure-symptoms referable to neighboring organs, and the depraved general condition would be in favor of a malignant disease. In rare cases, however, tuberculosis may take a similar course. Then microscopical and bacteriological examination of an excised gland will have to decide the question. The results of energetic treatment with arsenic may at times throw light upon the diagnosis. Leukæmic tumors may be readily recognized by the characteristic condition of the blood.

In old age it may be difficult to recognize the nature of an isolated enlarged gland, for it is usually found in places where malignant tumors are frequent (angle of the jaw, submaxillary region). Oftentimes excision of the tumor, which should always be done in doubtful cases, is the only method of determining the true nature of the disease. Circumscribed enlargement of glands surrounded by dense periadenitic fibrous tissue may give rise to difficulty in the differential diagnosis. This tumor mass may be confounded with primary or metastatic carcinoma, and, when situated in the supraclavicular fossa, with a cervical rib. When an individual gland breaks down, the possibility of cysts must be remembered. The presence of smaller glands around the larger swelling would be in favor of tuberculosis. In favor of a cyst would be a position in the neck typical of these tumors. In doubtful cases a test puncture may be performed. When tuberculous abscesses of glands are very large, the possible connection with suppuration in adjoining tuberculous joints and bones must be remembered (vertebral column, clavicle, sternum, etc.).

PROGNOSIS.—The prognosis is always grave, dependent on the type of glandular tuberculosis, the age of the patient, and the constitutional condition. The chief danger of the affection is its tendency to become general. This may take place: 1. By extension through the lymphatic system (pseudoleukæmic type). 2. By extension through the circulatory system with the development of miliary tuberculosis (rupture of a cheesy gland into the jugular vein); this may occur without apparent cause, or after acute local increase of symptoms, or in rare cases after operative interference. 3. By the development of pulmonary tuberculosis, which results fatally within a short time. 4. By the presence of multiple tuberculous foci in other organs (bones, joints, meninges). Generally speaking, tuberculosis of the neck is a type of tuberculosis that remains localized for a considerable length of time. The tendency to become general varies. There are benign and malignant cases. Another danger of more local nature is the persistence of chronic suppuration that may produce cachexia or amyloid degeneration of the abdominal viscera.

Spontaneous recovery may take place at any stage of the disease. Hyperplastic lymphomata are not infrequently observed to resolve and undergo fibrous contraction. When caseation is present, the focus may become encapsulated or calcified and the process remains stationary or resolves. Abscesses sometimes heal after rupture, and sinuses and ulcers may close after removal of the tuberculous tissue. The characteristic oftentimes extensive scars seen in healthy individuals give evidence of the healing power of nature. The tendency to spontaneous cure varies considerably, so that the question in an individual case, whether one is to rely upon this or not, must always be answered negatively. A tuberculous focus means danger to the entire organism, and should always be rendered inert by appropriate treatment as soon as possible.

TREATMENT—The removal of peripheral sources of infection, the excision of hyperplastic glands in children of tuberculous taint, and general hygienic measures may be of prophylactic influence. When the disease is well developed, general treatment may produce good results. Hyperplastic lymphomata are observed to grow smaller, and may even disappear under this treatment. Suppuration from sinuses may cease and ulcers of the skin heal. There are, however, limits to its successful application due to the intensity and extent of the tuberculous process. Even when surgical interference is necessary the value of constitutional treatment as a preliminary step is great, and it should not be neglected in the after-treatment.

The indications for surgical interference are when the glands increase in size in spite of prolonged continuous general treatment, and as soon as softening, abscesses, and sinuses appear.

Surgical treatment may be conservative or radical. The former consists of medicated injections into the glands, puncture of abscesses followed by injection; while the latter includes incision, curetting, and excision. When tuberculosis extends beyond the capsule of the glands, the condition is grave; the surgeon should try to prevent this by timely interference. There is no doubt that radical excision is the safest treatment, and were it not that one or more extensive scars always remain, should be recommended to patients, because the operation is practically without danger. As the subsequent appearance of these scars cannot be foretold in any individual case, it is justifiable to consider this objection. For this reason it may be advisable to avoid operation and adopt conservative methods. Cosmetic considerations, however, must not be made of more importance than the likelihood of recovery. Calot's assertion that glandular tumors where the skin is not involved should not be excised on account of the scar, cannot be accepted as long as there is no proof that injections give equally good results. By injecting chemicals into the gland-tissue it is sought to destroy the tuberculous tissue and produce contraction of the enlarged glands. Of all drugs that have been tried, iodoform in emulsion seems to have been most effective, and has recently been used chiefly in 5 to 10 per cent. solutions. French surgeons frequently prefer naphtholate of camphor. After inserting a trocar or fine needle into the gland, 15 or more grains of the drug are injected; this procedure being repeated at intervals.

Formerly it was not infrequent to have acute suppuration of the glands follow the injection of tincture of iodine, carbolic acid, or solutions of zinc chloride. Calot has recently reintroduced this method, and recommends the use of a 2 per cent. solution of zinc chloride for the purpose of artificially producing suppuration: 30 to 45 grains of this salt are injected into the gland every two or three days until softening takes place, which is usually after the third or fourth injection; the contents are removed by aspiration and naphtholate of camphor injected.

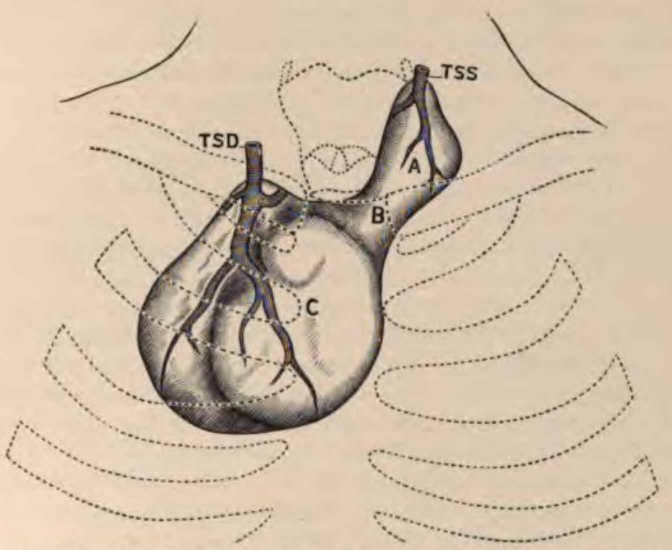
When intracapsular abscesses exist, the pus is removed and iodoform injected. This must at times be repeated after a short interval. After aspiration Cordua washes out the cavity with a 1 : 5000 solution of sublimate or a 4 per cent. solution of boric acid; after removing the trocar he presses out all fluid and applies a pressure-bandage so as to have the walls of the abscess cavity unite if possible.

With the injection and puncture method each individual gland must be treated separately, which makes it evident that this method cannot be successfully used in all cases. It is indicated in individual enlarged glands or in circumscribed tumors, each separate element of which is to be reached with a needle. There are, as far as can be ascertained, no extensive statistics showing the final results of this treatment.

The chief surgical treatment is excision. Excision alone is to be considered in the case of tumors with purely intracapsular processes. It corresponds to incision and curetting in cases with periglandular changes. Where the glandular tumor is movable, it may be removed with ease; the individual nodules may be shelled out separately or in groups by blunt dissection after incising the capsule. Larger vessels and nerves do not constitute a source of danger. Some attention must be paid to the cosmetic results and care be taken in choosing the line of incision, so that scars will be as little disfiguring as possible. The fact must, however, be remembered that the disease is always more extensive than would be supposed judging from appearances alone. The results of operation are the more favorable the more thoroughly all evidence of disease is removed.

Dollinger's subcutaneous method—incision behind the line of the hair and removal of the glands by blunt dissection after lifting off the soft parts—can be made use of only in exceptional cases—*i. e.*, when there are isolated glands near the seat of incision that have not broken down. When the glands are situated at some distance, Dollinger's method precludes certainty as to the arrest of hemorrhage. The author himself has injured the facial vein five times. Another danger consists in infecting the wound with the contents of broken-down purulent glands. This sort of infection may be avoided by an open incision and careful manipulation of softened glands.

FIG. 29.



Intrathoracic thyroid: TSD, right superior thyroid artery; TSS, left superior thyroid artery.

In small tumors in the submaxillary region it is best to make a horizontal incision immediately below the margin of the jaw, and in the submental region a longitudinal incision from the spina mentalis to the hyoid bone will be indicated. In the region of the sternomastoid an incision parallel to the margin of the muscle is most convenient, and with glands in the supraclavicular fossa the incision should be parallel to the collar bone. Masses of glands occupying almost half of the neck demand extensive incisions. Deforming flap incisions may usually be avoided in the variety of glands under consideration, for sufficient room can be obtained by two incisions along the anterior and posterior margins of the sternomastoid throughout its length. Injury to important nerves, especially the spinal accessory, is always to be avoided. As excision is not technically difficult, and does not take much time even when the disease is extensive, one should always try to remove even the smallest glands that can be reached, so as to prevent recurrence. After stopping all bleeding the wound is closed by a continuous suture, except a small space left for drainage. Packing the cavity of the wound with iodoform gauze is only necessary when the infected contents of caseous or purulent glands have been discharged over the surface of the wound during operation.

In cases complicated with periadenitic processes the choice of method depends on the extent and seat of the disease, support on part of the patient, and the general condition. If the gland is broken down, isolated, and adherent to the skin, the abscess may be incised, the tuberculous tissue removed, and the cavity packed with iodoform gauze. It is, however, safer to make an elliptical incision around the entire abscess and remove the whole *in toto*, for in a case of this sort one is often enabled to remove neighboring glands that are diseased. Simple incision is usually not sufficient with subcutaneous abscesses, because the gland giving rise to the abscess usually lies below the fascia. The seat of perforation must be sought for, enlarged, and the broken-down gland curetted. When these indications are not considered, there is apt to remain a sinus with protracted suppuration. If a larger group of glands is diseased and abscesses exist that have not been opened, one should first try incision and curetting. Any deep-seated pus focus may then be opened, and the cavities packed with iodoform gauze to keep the wound open. If a patient is young and can withstand energetic general treatment in connection with an operation, complete recovery may follow in a number of these cases. Frequently, however, it is necessary to repeat the operation several times because of recurrence. If glandular tuberculosis comes for treatment when sinuses and ulcerations are present, then the undermined skin must be excised and the sinuses opened and traced to the primary foci. Thorough curetting of the exuberant granulations is indicated, and sometimes a cautery may be used. Complete excision should be decided upon secondarily when the above-named methods have not given the desired results or when the disease progresses; primarily when masses of enlarged glands occupying the entire side of the neck, with solid adhesions and abscesses and sinuses, are encountered at first. In cases of this sort the possibility of obtaining a good result by simple incision and curetting is not to be thought of. The success of operating on adherent glands is still more dependent on thoroughness than is the case with the movable variety. Partial excision is useless. If caseous infiltrated fibrous tissue and bits of gland remain, sinuses form that are patent for the rest of life.

The jugular vein is no longer a noli me tangere. If this vessel is too adherent to the mass of glands, it may be ligated and resected without fear, for it has been compressed for some time and has become of less importance for the circulation. Billroth (Fränkel) resected this vein without disadvantageous results in 16 of 148 cases, and a like experience has been reported by other operators. Firm adhesions to muscles, vessels, and nerves make the operation difficult, and only a surgeon familiar with surgical technic and anatomy should attempt it. Hemorrhage is the chief danger, especially from veins. The field of operation should be exposed by free incisions without regard to cosmetic effect. Flap-incisions are therefore best, either T or H shaped or angular (horizontal arm below the margin of the jaw, vertical one parallel to the sternomastoid). If the sternomastoid cannot be separated from the mass of glands and has undergone fibrous degeneration, it may be divided below the spinal accessory nerve. But even in cases in which it is not degenerated temporary division is to be recommended when enlarged glands adherent to the vessels are situated directly beneath. The spinal accessory nerve should be avoided as much as possible and dissected out of the surrounding fibrous tissue. If, however, it is too extensively involved by the mass of glands to be dissected out, it may be necessary to sacrifice it even though the trapezius muscle is paralyzed in about two-thirds of the cases. In spite of the dense adhesions to the internal jugular vein, it is possible in the majority of cases to separate this vessel from the mass of glands. In doing this it is advisable to place a provisional proximal ligature around the vein. One is never obliged to ligate the carotid, resect the vagus or sympathetic, for it is always possible to separate these from the glands. When the disease is very extensive, it is at times necessary to carry the dissection down to the spinal column or into the supraclavicular fossa down to the trachea and œsophagus, so that after removal of the mass one has a complete dissection of one-half of the neck. The wound is freely drained or packed and the skin-incision closed as much as possible after excision of all diseased portions. The dressing should cover the head, neck, and part of the chest so as to guard against infection. The reaction even after most extensive operations is, as a rule, slight, and recovery takes place within a short time, provided no secondary complications arise. The mortality from the operation has diminished to practically nothing. Of 429 operations on glands of the neck that have been performed in the author's clinic, not a fatal case occurred as a result of the operative interference itself.

Statistics give abundant information as to the after-results of operative treatment. Of 328 cases treated between 1886 and 1895, 140 were subsequently examined, and of these 82 were of value in forming an opinion as to the final result, for six years or more had passed since the operation: 43 of the 82 patients (52.4 per cent.) were permanently cured—that is, free from any glandular swelling whatsoever. If eight years free from recurrence be demanded for a final result, there remained 45 cases with 25 cures—*i. e.*, 55 per cent. On the other hand, if the final result is based on cases in which at the seat of operation no recurrence had taken place after six years, then 17 cases may be added to the above—*i. e.*, 20 per cent. The percentage of those permanently cured by the operation is therefore about 73.1. These results appear especially favorable if it is taken into consideration that of 140 operative cases periadenitic processes (adhesions and abscesses) were present in 90. Excision was performed in 85 cases, curetting in 43 cases, in 5 cases incision, and in 7 cases combined methods. In 69 cases a permanent result was obtained by one operation, whereas secondary operations were necessary in the others. On subsequent examination recurrences in the vicinity of the wound were observed 42 times—*i. e.*, in 30 per cent. of the cases; and recurrences in the widest sense of the word—*i. e.*, glandular swellings anywhere—in 72 cases, or 51.4 per cent.

Fränkel collected the material of Billroth's clinic in 1885 and was able to determine the final result in 48 of 148 cases. Of these 48 patients, 34—*i. e.*, 71 per cent.—were cured, but only 12 for more than three and a half years. Local recurrence was present 7 times—*i. e.*, in 14 per cent. of the cases. Wohlgemuth, in 1890, had a similar percentage of permanent cures in 81 children operated on during the first decade of life. After 45 total excisions he obtained 26 permanent cures—*i. e.*, 70 per cent.; and after 36 incisions and curettings, 17 successful results—*i. e.*, 63.9 per cent.; and of 46 cases not operated upon, recovery was observed only 11 times—*i. e.*, in 24 per cent. From these statistics the superiority of operative treatment and the advantage of excision over incision and curetting are apparent.

Fürnrohr obtained the following results at Erlanger's clinic: of 87 patients in whom the final results could be obtained, 36—*i. e.*, 41.4 per cent.—were permanently cured; in 29—*i. e.*, 33⅓ per cent.—recurrence had taken place; and 23—*i. e.*, 26.4 per cent.—had died from tuberculosis since the operation. Blos calculated from 11 different statistics comprising 745 cases that following operation there were 54 per cent. of permanent cures, 28 per cent. of recurrences, and 18 per cent. of deaths. The influence of excision of glands on existing tuberculosis of the lungs is of especial interest. The author's experience is as follows: of 20 consumptives, included in 140 cases, 16 were found cured at a later examination. Of these 16 cases, 11 were at the same time free from glandular recurrence, consequently removal of the glandular focus was followed by disappearance of the pulmonary lesion in 80 per cent. of the cases. Lung complications developed in 13 other cases some time after operation, so that on subsequent examination tuberculosis of the lungs was found present in 17 of the 140 cases. Of these 17, 11 had fresh glands, whereas 6 were free from glandular involvement.

As far as the scar is concerned, of 108 cases subsequently examined, 48 had very good, even ideal scars after excision, 3 good scars after curetting, 9 had ugly scars after excision, and 48 had disfiguring scars after incision and curetting. These figures show that even from a cosmetic standpoint radical operation gives much better results than more conservative interference.

Syphilis of the Lymph-glands of the Neck.—The lymph-glands of the neck may be involved in all three periods of syphilis.

Primary syphilitic swelling of the glands is found almost exclusively in the upper part of the neck, in the submental or submaxillary region, or near the angle of the jaw, because it is usually secondary to primary lesions of the tongue, the lips, or the tonsils. Compared with the inguinal glands, the affected cervical glands are apt to become much larger, are oftentimes painful, and show evidence of periadenitic adhesions. Tumors the size of a goose-egg may develop. They are apt to be fixed and cannot always be shown to consist of several small glands. The rapid development of glandular enlargement in individuals otherwise healthy is extremely characteristic, and indicates the nature of the disease. Examination of the mouth will confirm this preliminary diagnosis.

In secondary syphilis, owing to general infection, all the glands of the neck are enlarged. They may remain stationary in size for several years. The size varies between that of a pea and that of a large bean; they are hard, movable, and painless. Simple hyperplastic glands alone enter into the differential diagnosis, but are easily excluded (proof of the presence of syphilis and absence of any peripheral disease sufficiently severe to cause such extensive glandular enlargement).

In the tertiary period gummatous lymphomata of the neck occur very rarely, but when present are in the submaxillary region usually, and are about the size of a walnut. They grow very slowly and are not painful or sensitive to pressure. They are of dense elastic consistence, and at first are without adhesions. After existing for some time they soften, become adherent to the skin, and rupture externally, leaving a characteristic ulcer. Only in rare cases do they subside spontaneously. As other signs of syphilis are frequently absent when these tumors appear, the diagnosis is oftentimes difficult and can rarely be made except by the use of potassium iodide. Microscopical examination during the stage of hyperplasia does not reveal anything characteristic.

Neoplasms of the Lymph-glands of the Neck.

Primary Lymphosarcoma of the Neck.—This term includes several types of disease that have certain characteristics in common, but present such differences in other respects that some sort of classification seems desirable. There does not seem to be any uniform opinion in this direction. Nearly every pathological anatomist and clinician has his own views on this subject, so that the same name is oftentimes applied to very different conditions. Hodgkin's disease, anæmia lymphatica (Wilks), progressive multiple hypertrophy of the lymph-glands (Wunderlich), pseudoleukæmia (Cohnheim), lymphosarcoma (Virchow), adenie (Trousseau), malignant lymphoma (Billroth), malignant lymphosarcoma, are terms that fitly illustrate the confusion existing on this subject. The difference of opinion is due to the fact that there does not exist a histological differentiating criterium of the various kinds of lymphosarcoma. They cannot be differentiated etiologically because the primary cause of the disease is not known. Even if it must be acknowledged from a pathological standpoint that the various types of the disease cannot be sharply separated, yet it is desirable for practical reasons and justifiable from a clinical standpoint to group these growths in some way.

It is sufficient for clinical purposes to have two types: malignant lymphoma and lymphosarcoma proper.

Malignant Lymphoma.—This disease is characterized by a gradually increasing hyperplasia of the lymph-glands that cannot be controlled and that terminates fatally without change in the numerical relation of the red and white blood-cells. In the majority of cases metastases occur in the internal organs. These correspond in structure to the primary glandular condition. The process is always limited to the individual glands affected, which never show any tendency to become otherwise altered. The capsule of the gland is always exempt. There is no extension to the surrounding parts, no adhesion of the tumors with adjoining tissues. Neighboring organs may be displaced or compressed just as with benign tumors. Histologically malignant lymphoma is identical with simple hyperplasia of all the glandular elements. There are two subdivisions, depending upon whether the connective tissue or the cellular portion of the gland is more affected. The nodes may be correspondingly hard or soft.

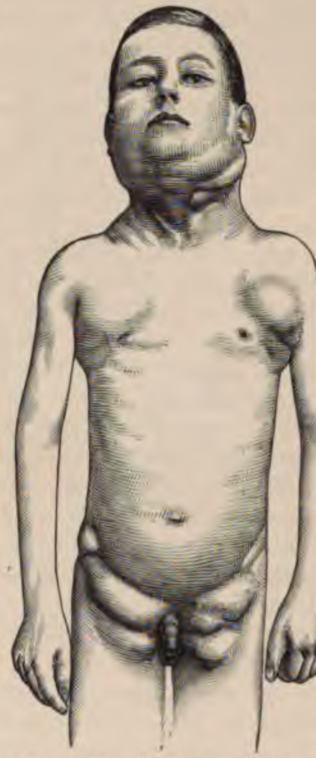
Soft Type.—The glands are very soft, almost fluctuating, and are held together by loose connective tissue. The cut surface is grayish red, homogeneous, marrow-like. Microscopically the gland-substance and marginal substance are no longer to be differentiated. The lymph-corpuscles are much increased and completely fill the delicate connective-tissue framework. The lymph-gland character is preserved.

Hard Type—The glands are hard round nodules that appear white on section and consist chiefly of connective tissue. Only in scattered areas are there accumulations of lymphoid cells, either in the meshes of the delicate connective-tissue framework or in the dense connective-tissue bands.

Besides the ordinary lymph-corpuscles, larger epithelioid cells and isolated giant cells have been repeatedly found. The latter, however, never show the structure of typical Langhan's giant cells. Goldmann has called attention to the abundance of eosinophiles and the presence of so-called "kugel" cells. The results of Goldmann's investigations have been corroborated by other scientists. Still the hope that the eosinophilic granules might be made use of in a differential diagnostic way has not been fulfilled. Kanter and Fischer have demonstrated the same cells in other lymphatic diseases (tuberculosis, acute lymphadenitis). The presence of numerous eosinophilic cells is nevertheless of diagnostic importance even if it does not permit of positive conclusions. Both the hard and the soft form show numerous transitional stages which may be represented in one and the same gland. According to Winiwarter, the soft type is to be considered the younger type, whereas the hard type is considered an advanced stage of the same condition. Fischer has recently come to a like conclusion based on the conditions found at autopsy. As is shown in Hübner's observations and statistics, there are cases in which soft lymphoma alone may persist to the end. Retrograde changes are absent. Softening and necrosis are probably always the effect of treatment. Dietrich was able to detect primary foci of coagulation-necrosis in only two cases and only in one gland in each.

The clinical course is typical. Individuals between fifteen and thirty-five years of age are usually attacked. The affection is also common in children, but rare in those of advanced years. The male sex seems to be more frequently subject to the disease. The enlargement almost always begins in the neck, a swelling of the glands appearing in a patient that up to this time has been apparently well. There is usually no cause to be assigned. The enlargement first takes place on one side of the neck, and increases in size without causing any particular disturbance or attracting especial attention. The neighboring glands gradually enlarge, and in the course of weeks or months nodular tumors are formed that occupy the entire half of the neck from the jaw down to the collar bone. The general condition is undisturbed. The appearance is fresh and healthy; there is no discomfort. The lymph-glands in other regions of the body and other organs are not affected. Suddenly a rapid increase of growth takes place. At the same time the glands of the other side of the neck become visible. The glands of the axilla, inguinal glands, and epitrochlear glands become involved. Difficulty in breathing and coughing indicates involvement of the bronchial and mediastinal glands. The general condition in the meantime becomes worse. The patients are anæmic; feel tired and weak, get thinner and thinner, lose appetite, and become cachectic. Œdema, ascites, pleuritic effusions, diarrhœa, and decubitus develop and death supervenes. The disease does not always pursue this course. In some cases the severe general symptoms do not develop because the patients succumb at an early stage to some local effect of the tumor, while the general physical condition is good. The trachea is displaced by unilateral enlargement of the neck, or it is compressed bilaterally. Death from suffocation may follow constriction of the pharynx by a tumor of the

FIG. 30.



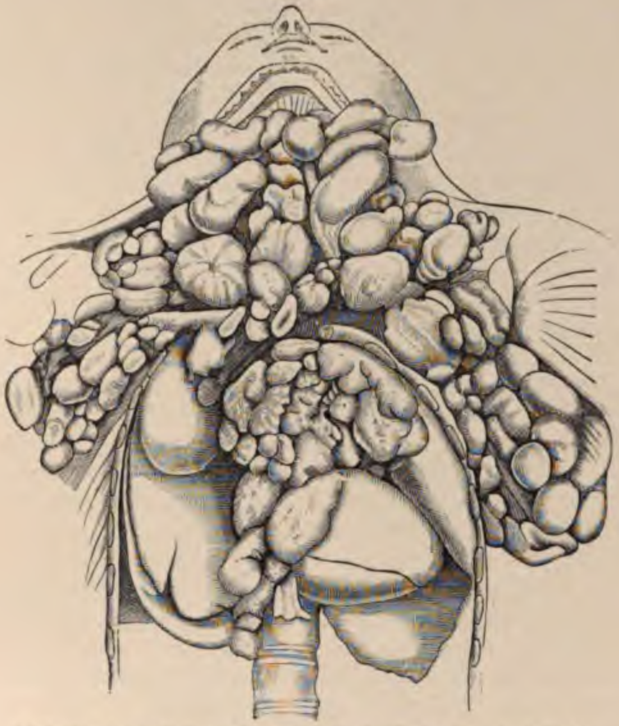
Malignant lymphoma in a boy fourteen years of age. (v. Bruns.)

tonsil. Pressure on the œsophagus causes difficulty in swallowing and marked disturbance of nutrition. Investigations of Fischer have shown that the relation of the white and red blood-corpuscles remains normal throughout the entire disease. The white cells are never increased in number. On the other hand, toward the end of the disease there is a decrease of the blood-elements in general and marked diminution in the amount of hæmoglobin. When the disturbance is marked, a symptom appears to which especial importance has been attributed: so-called recurrent fever. The temperature gradually rises to 40° C. or higher, remains at this level for some time, and then drops by crisis. In a case observed by Fischer ten such attacks of fever were noted in three hundred and fourteen days, and lasted from ten to twenty-one days apiece. During the febrile period no changes were evident, either in the glands, the spleen, or the internal organs. Bacteriological examinations of the blood and lymph-glands during the fever period showed pure cultures of *Staphylococcus aureus*, whereas similar experiments during the fever-free period were negative. Post-mortem examination of glands shows no micro-organisms, and the autopsy shows no pus focus in the body, so that Fischer believes that the fever is due to secondary infection, contrary to Ebstein and Pel and others, who consider the fever a symptom of the original disease.

Anatomical Relations (Fig. 31).—The glandular masses in the neck can usually be divided into three groups, separated by folds. The first group is situated in the region of the angle of the jaw. The second group occupies the middle triangle of the neck and reaches from the trapezius to the larynx and trachea; the sternomastoid is superficial to this mass of glands. The third group is above the collar bone. The carotid artery with the vagus, as shown by Braun's frozen sections, is deeply situated at the side of the œsophagus, whereas the internal jugular vein is pushed forward almost to the surface and is considerably compressed. The size of the individual glands varies between that of a bean and that of an apple. The outline of the individual glands is usually preserved. There are no changes in the overlying skin, but dilatation of the veins may be present when the mass of glands is large. The tumor is freely movable either in its individual parts or *in toto*, provided the size of the growth is not extreme. In typical cases there are no periadenitic adhesions, and where such are present they are probably due to secondary changes of inflammatory nature, produced by therapeutic measures or by mixed infections. In some cases all the lymphatic glands of the body are involved and a corpse presenting this condition is well adapted for the study of the normal topography of lymphatic glands. The increase in size of the bronchial glands may be so considerable that the lung is surrounded and partially compressed by the masses. Groups of glands sometimes extend into the interlobular spaces. Glands have also been noticed at the porta hepatis at the head of the pancreas, and at the hilus of the spleen, intimately adherent to the parenchyma.

In many cases of malignant lymphoma metastases are observed, but may be entirely absent, and are therefore not considered characteristic of the disease from a diagnostic standpoint. The author considers as metastatic growths only those occurring in organs not connected with the lymphatic system. Metastases, as already mentioned, have the same structure as the gland, may be hard or soft, are provided with a capsule, do not undergo retrograde metamorphosis, and vary greatly as to their size. Metastases are most frequently found in the lungs, then in the spleen, the liver, the kidneys, and sometimes in the marrow of bones. The organs affected present nodules from the size of a grain kernel to that of an apple. Sometimes the organ involved is increased in volume, which in the case of the spleen resembles a true splenic cake. These metastases usually develop in the connective tissue of the parenchyma, especially in the connective-tissue sheaths of the vessels. They do not possess any particular clinical interest because they can usually not be detected. The nature and cause of malignant lymphoma are not known. As yet it has not been agreed upon whether the disease is to be classified with the tumors or with infectious diseases. Many authors claim that owing to the clinical signs some infectious process is the cause. However, the endeavors to

FIG. 31.



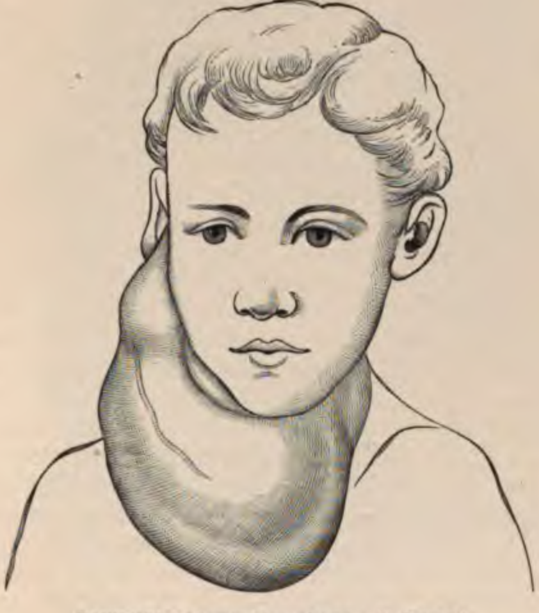
Malignant lymphoma in a woman thirty years of age. (v. Bruns.)

discover a specific organism have been fruitless. The presence of staphylococci and streptococci in the glands demonstrated by Maffuci, Majocchi, and Picchini is in all probability explained by secondary infection. Delbet's statement that he cultivated a bacillus in malignant lymphoma and produced the disease in dogs by injecting pure cultures, has not been corroborated. The view that malignant lymphoma is of tuberculous origin has been proved wrong. The negative results of Fischer's investigations are more important than the above statements. He examined the blood as well as the glands bacteriologically in 12 cases. The blood was always shown to be free from bacteria, and in the glands no micro-organisms could be demonstrated with a microscope or by culture. Inoculation of animals with particles of the gland-tissue was always negative. Malignant lymphoma is not infrequently associated with tuberculosis, which explains the view that both conditions are connected etiologically. The observations of Delafield, Askanazy, Weishaupt, and Dietrich have shown that there is a rapidly fatal type of glandular tuberculosis, presenting a clinical picture typical of malignant lymphoma (pseudoleukæmic form). Bacteriological and microscopical examination is frequently the only way of determining the true nature of the disease, because the cut section of a gland may show no signs of tuberculosis macroscopically. The presence of tubercles and bacilli will always prevent confounding with malignant lymphoma. The occurrence of tuberculosis in internal organs during the course of malignant lymphoma is not unusual in the advanced stages of the disease. Tuberculosis of the lung is a frequent fatal complication, and should be suspected where the constitutional signs are especially marked. Fischer found tuberculous changes in the lungs, liver, spleen, and intestines that seemed to be recent in 2 cases that came to autopsy, but was not able to demonstrate even a trace of tuberculosis in the malignant glands either microscopically or with cultures or by injecting animals. He therefore considered tuberculosis a secondary infection of the weakened organism. In view of the frequency of latent glandular tuberculosis, it is not astonishing to find tuberculous glands and malignant glands present at the same time. Cordua's case, in which the bronchial glands were found caseous, belongs to this group. Malignant lymphoma may become secondarily infected with bacilli when miliary tuberculosis is present, as shown by the cases of Brentano, Tangl, and Wätzold. The author therefore agrees with Fischer and Dietrich that malignant lymphoma and tuberculosis of the glands themselves or of other organs may be combined, but that there is no etiological connection.

Diagnosis.—A diagnosis is usually easy in a well-developed case, but is oftentimes impossible clinically in the early stages of the disease. The condition may be confounded with simple hyperplastic lymphoma, leukæmia, or tuberculous lymphoma. Against the latter would be the absence of peripheral foci of infection (carious teeth, eczema, blepharitis); against leukæmic tumors, the normal condition of the blood; against tuberculosis, the absence of hereditary taint, tuberculous signs elsewhere, the absence of retrograde metamorphoses or inflammatory conditions. However, as tuberculosis of the glands may pursue a course identical with that of malignant lymphoma, excision of a gland for diagnostic purposes is justifiable in doubtful cases. Animals should be inoculated if necessary, because, as shown by Fischer's experience, even microscopical examination may fail. In one of his cases there were present microscopically abundant eosinophilic cells, lymphocytes, and very few epithelioid cells, whereas giant cells, retrograde changes, and tubercle bacilli were absent. Nevertheless, inoculation of rabbits with gland-tissue demonstrated tuberculosis. The clinical course of the case supported this diagnosis. Extensive enlargement of the glands occurring in the upper regions of the neck in syphilis, when the primary lesion is in the region of the face or in the mouth (lips, tongue, tonsils), will hardly ever be mistaken for malignant lymphoma, because of the primary lesion. Secondary lymphatic enlargements are usually easy to exclude if their cause is sought for (malignant tumors of the mouth, pharynx, œsophagus, and larynx).

Prognosis.—The prognosis is hopeless. The course is at times rapid, at times slow. Death may take place within from six months to two years.

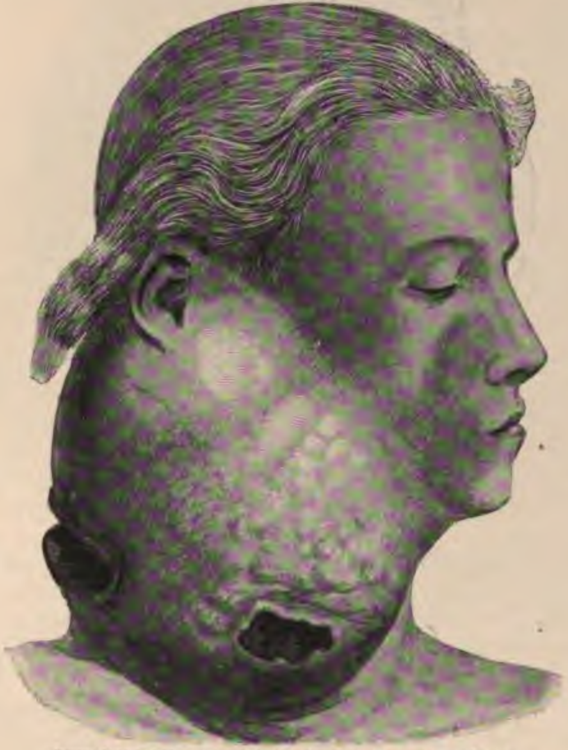
FIG. 32.



Recurrent malignant lymphoma. (v. Bruns.)

Treatment.—It is of great importance in the treatment to recognize the nature of the disease early. If a purely local process could be considered, early and radical excision would check its progress. If, however, the affection is a general disease of the glands, then surgical interference offers no hope. As yet no proof is at hand to show that the disease is produced by an organism. On the other hand, experience is in favor of a general infectious disease of the lymph-glands because excision is always followed by recurrence. (Fig. 32.) A case of permanent cure after operation is yet to be reported. Billroth, on the strength of his experience, operated in cases of malignant lymphoma. In spite of this prospect it is justifiable at times to use the knife, especially in the earlier stages of the disease when the diagnosis is doubtful, and furthermore when pressure-symptoms develop referable to organs important to life, such as the trachea and œsophagus. Excision of the tumors even when very extensive is not difficult technically, owing to the absence of adhesions, and the wound as a rule heals rapidly without disturbance. It is justifiable, therefore, to make an attempt to cure by removing the new growth. Operations on recurrences are to be condemned, however, as useless. Considering the hopelessness of surgical treatment, efforts have been made to influence this disease medically. Billroth was first to obtain a brilliant result by administering arsenic in a case of advanced disease. The masses of glands were made to disappear or were reduced to a minimum. Further experience has shown that arsenic seems to have almost a specific influence in individual cases, but that in others its use is followed only by temporary diminution in the size of the glands or it may have no effect whatsoever. It is doubtful whether permanent cures have been produced by treatment with arsenic. The drug may be administered internally or subcutaneously. When given internally, it is well to begin with small doses, as recommended by Billroth, and then increase up to a certain point, gradually returning to the initial dose. Five drops of Fowler's solution with an equal quantity of tincture of amara are given as the initial dose. In the course of two to three days this may be increased to ten drops in two doses, then fifteen, twenty, or forty drops, finally returning to the first dose. The drug is omitted for several days only after signs of poisoning appear; otherwise it may be continued for months. After arsenic has been used for a few days the glands become smaller, more movable, and softer. After eight or ten days the glandular masses almost always become tender, without local signs of inflammation. Subsequently they diminish rapidly in size and become hard and firm. In individual cases inflammation and suppuration takes place. Afternoon fever [illegible] [illegible], which, however, has but slight effect on the general condition. During the fever the tumors oftentimes diminish [illegible] [illegible]. The general condition and nutrition are favorably [illegible] [illegible] arsenic provided toxic symptoms do not occur. A preparation [illegible] sodium arsenate in granules. It is well to begin [illegible] granules a day and increase [illegible] every four days until 18 [illegible] and then return [illegible] dose. Czerny in 1872 [illegible] injections of arsenic [illegible] gland-substance. This [illegible] used with success by Billroth [illegible] cases of malignant lymphoma. Strict asepsis must be observed to prevent abscesses. One drop of Fowler's solution is used at first, injected daily in different places as long as no marked signs of inflammation occur. Radiating pains usually appear at the seat of inoculation several hours after the injection, but soon subside. The gland treated is not sensitive. The local and general effect otherwise is the same as with the internal use of arsenic. Favorable results have repeatedly followed internal administration and parenchymatous injections combined. It may at times be beneficial to use both methods alternately, as recommended by Czerny. Ziemssen recommends subcutaneous injections because he considers this method more effective and less dangerous. He uses a 1 per cent. solution of sodium arsenate, beginning with a quarter of a hypodermic syringeful daily and after a few days giving one-half, gradually increasing to one syringeful twice daily, the final daily dose being $\frac{5}{16}$ grain. This quantity was borne without disturbance.

FIG. 33.

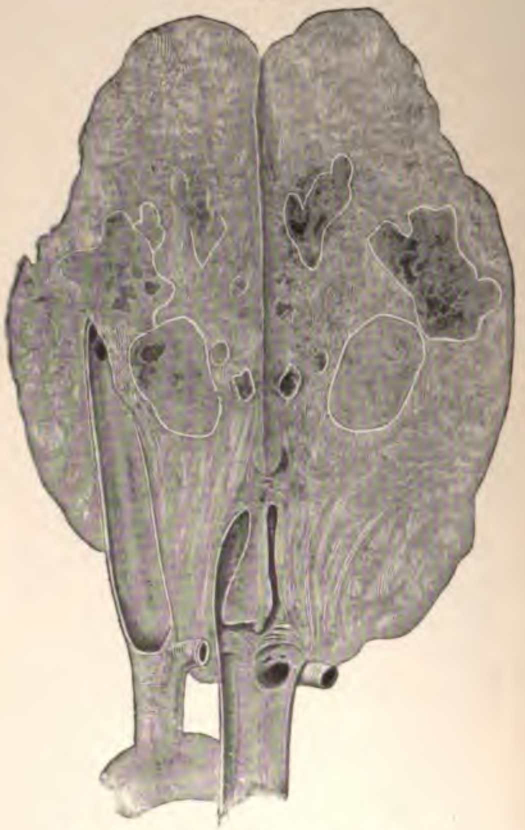


Lymphosarcoma in a woman twenty-five years of age.

Katzenstein cured a man thirty-seven years of age with advanced pseudoleukæmia after 100 injections given over a period of six months. The patient was said to be in good health after two years. He commenced with injections of a 0.01 per cent. Fowler's solution every third day, increasing the strength by 0.05 per cent., and finally used a syringeful of pure solution twice a day without producing toxic symptoms. He then gradually returned to the primary dose. Every two weeks treatment was suspended for several days.

Lymphosarcoma.—Lymphosarcoma is an enlargement of lymph-glands that increases rapidly, perforates the capsule, and extends to the surroundings. The neighboring organs are infiltrated by the new growth or surrounded by it, and finally the skin becomes involved and perforated. Lymph-glands in neighboring regions and those more distant remain free from metastases, which, however, are found in the internal organs. Histologically the tumor is a sarcoma, the cells of which present the type of lymph-cells. In some cases a fine reticulum persists, so that it may be impossible to differentiate microscopically between a benign and a malignant hyperplastic lymphoma. Retrograde changes may be absent, but in many cases they are more or less extensive. Most authors consider sarcoma of the lymph-glands as a distinct

FIG. 34.



Involvement of vessels by malignant growth.

disease from lymphosarcoma. The former develops from the connective-tissue portion of the glands and has the character of a spindle-cell or alveolar sarcoma. The course and termination of both diseases are identical; therefore no separation is possible clinically. Furthermore, the histological differential diagnosis is often difficult (in lymphosarcoma there are at times large cells resembling spindle cells). Finally, sarcoma of the glands is extremely rare, which makes it justifiable to consider the two types under one heading from a clinical standpoint. By combining these two the subject is much simplified.

Symptoms.—In the early stages of the disease, during which, however, the patient does not often come under observation, there is found beneath healthy skin, a smooth, movable, painless tumor, presenting the characteristics of a soft hyperplastic lymphoma. As this increases in size new nodules of similar consistency appear at the periphery, finally becoming incorporated in the primary tumor, so that a nodular uniform mass develops. Subsequently the tumor becomes adherent to the underlying tissue, extends to the muscles and skin, surrounds muscles and nerves, and infiltrates the jugular vein, giving rise to thrombi (Fig. 34). The trachea is pressed to one side and compressed by the tumor occupying the whole half of the neck. The œsophagus is compressed, leading to complications that may be fatal. The skin is frequently perforated; the protruding mass of tumor disintegrates, followed by hemorrhages and suppuration. The tumor is usually of soft consistence, almost fluctuating. Local secondary symptoms or internal metastases are eventually followed by a fatal termination. The course is rapid, rarely extending over a year and a half.

Treatment.—Diminution in the size of the tumor has been observed in individual cases, especially after parenchymatous injections, but an absolute cure has probably never been effected. Furthermore, as serum-therapy has not fulfilled expectations, excision remains as the only means affording any chance of recovery, and this only in the early stages of the disease. Even if operative interference is impossible when the growth is well advanced, palliative measures, such as curetting and cauterizing with zinc chloride, and tracheotomy, are to be considered.

Secondary Malignant Involvement of Glands.—Carcinomatous glandular metastases occur frequently when the primary focus is in the region of the lips, tongue, jaw, the tonsil, the skin of the face and head, the larynx, the œsophagus, the salivary glands, the thyroid glands, or the breast. It may at times be almost impossible to find the primary focus, so that the diagnosis of the nature of firm gland tumors is not always easy. They may very readily be confounded with branchiogenic carcinoma.

Metastatic sarcomata of glands are not infrequent, although not so common as carcinomatous glands of the neck. They are found especially in angiosarcoma of the carotid, submaxillary salivary glands, thyroid gland, jaw, etc.

TUMORS OF THE NECK (GLAND TUMORS EXCLUDED).

Cystic Tumors of the Neck.

Congenital Cysts or Cysts due to Anomalies of Development.— **Branchiogenic Cysts.**—These tumors are observed in the anterior region of the neck in the middle line or at the side. The lateral ones are usually situated between the larynx and the sternomastoid, rarely between the mastoid and the hyoid, or in the lower triangle. They may involve under certain circumstances the entire half of the neck. The median cysts are situated above or below the hyoid bone, but may be anywhere between the thyroid cartilage and the jugulum. The size varies, but is usually not greater than that of a hen's egg. The shape is usually oval. They are of elastic consistency and distinct fluctuation is generally present. The overlying skin is normal and can be lifted off everywhere. The mass is usually more or less movable superficially, but fixed at its base. It is not sensitive to touch.

Fig. 35.

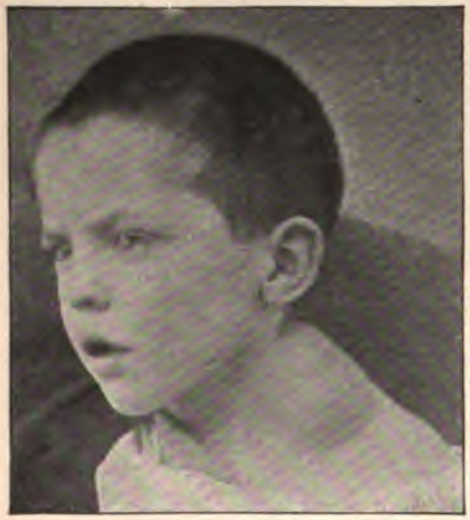
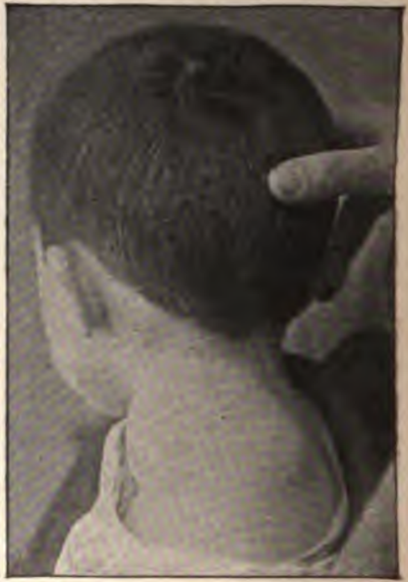


Fig. 36.



Branchial cyst. (Dennis.)

These cysts are rarely congenital, but develop during the first three decades of life, most frequently after puberty. In rare cases they develop in individuals well advanced in years. The same genetic and histological conditions apply to cysts as to sinuses of the neck. The former subdivision of cysts into those from the second, third, and fourth branchial clefts, according to the level of the tumor in the neck, is therefore unjustifiable. It must be assumed that the lateral cysts in all probability are derived from the second branchial pocket and cleft, the median ones from the inductus thyroglossus and from the sinus cervicalis.

These cysts may be due to intra-uterine or extra-uterine closure of a branchial sinus at both ends, to obliteration of an incomplete sinus at its orifice, to partial persistence of the branchial cleft, and finally to proliferation of epithelial cells shut in by closure of the sinus cervicalis.

The cyst-wall corresponds in its structure absolutely with that of the sinus. It consists of an external connective-tissue and an inner epithelial layer. According to the origin, the epithelium is squamous or fimbriated or cylindrical. The epithelial membrane appears in various stages of development either as several layers of simple squamous epithelium or as epithelium with rudimentary papillæ, or with completely developed epidermis (rete Malpighii, glands, hair). It may be of ectodermal or endodermal origin. The endodermal variety is always characterized by the presence of lymphoid tissue in the cyst-wall. In some cases both kinds of epithelium are found at the same time, in which case the cyst must have arisen from portions of the branchial cleft near the dividing membrane.

The external layer of the wall is sometimes composed of dense, sometimes of soft connective tissue, which may be very vascular, or contain considerable lymphoid tissue. The latter may at times be so abundant that the cysts are believed to have developed from lymphatic tissue. (Lücke, Gussenbauer.) In rare cases cartilage and striped muscle-fibres have been found in the cyst-wall. Aside from monolocular cysts, which are by all odds the most common, multilocular cysts are observed that may contain different sorts of epithelium in one and the same cavity or in the different cavities. (Zöppritz.) This condition will be easily understood if it is remembered that with sinuses it was not uncommon to find multiple subdivisions of the canal. (Fig. 37.)

The contents of the cyst are the product of the lining epithelium and vary correspondingly. Some cysts have pure serous, some mucous, and some thin or thick sebaceous contents with or without hair. All sorts of intermediate conditions may be found. It is therefore not justifiable to classify these tumors as serous (hydrocele colli), deep sebaceous, and dermoid cysts.

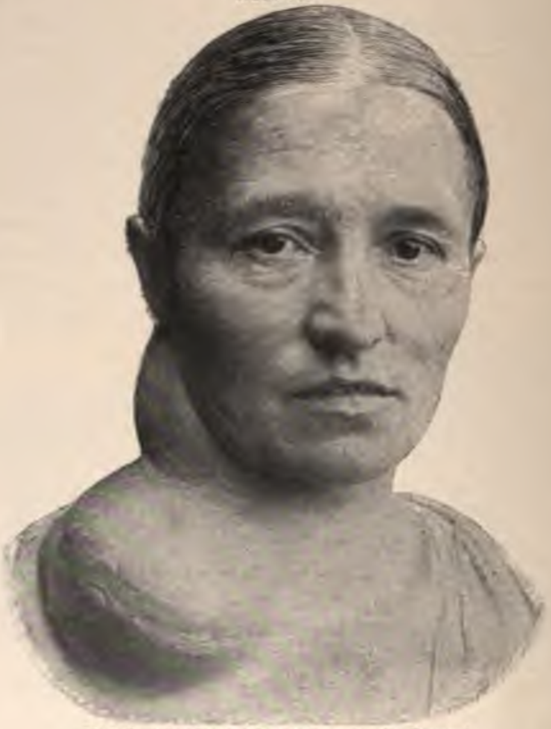
The anatomical relations correspond to those of the sinuses. Lateral cysts are usually situated on the sternomastoid or along its anterior margin, but may develop underneath and be more or less firmly adherent to the sheaths of the great vessels. They may extend upward toward the styloid process and downward toward the pharynx. Not infrequently they are closely adherent to the pharynx or to the cornu of the hyoid bone. The median cysts arise either from the ductus thyroglossus, and are then above the hyoid bone and contain endodermal squamous epithelium (ductus lingualis), or below the hyoid bone, and are lined with fimbriated epithelium (ductus thyroideus).

Thyroid gland follicles have been found in the cyst-wall. (Häckel.)

The cysts, just as the fistulæ, are often intimately adherent to the hyoid bone. The combination of cysts and sinuses in the course of the ductus thyroglossus is an interesting pathological condition.

SYMPTOMS.—The clinical signs produced by branchiogenic cysts are insignificant. Inconvenience from pressure on the neighboring organs arises only when the tumors are unusually large. They develop quite slowly.

FIG. 37.



Multilocular branchiogenic cyst. (v. Bruns.)

DIAGNOSIS.—The diagnosis is often very difficult. They may be confounded with cysts of other origin (cystic lymphangioma, goitre), or with cold abscesses that present the same clinical symptoms. In doubtful cases aspiration may give the desired information—*i. e.*, microscopical or chemical examination of the contents. Aside from the contents, the kind of epithelium found will be characteristic of the cyst.

PROGNOSIS.—The prognosis of the condition itself is favorable, but may become grave on account of complications, especially when carcinomatous degeneration of the cyst-wall takes place.

TREATMENT.—Excision is the safest way of getting rid of the cyst. This may at times be difficult on account of adhesions to the vessel-sheaths and the jugular vein. It may be necessary to ligate or resect the latter vessel. Separation from the pharynx, styloid process, and the cornu of the hyoid bone may be almost impossible. The results of operation are, however, favorable. Recovery took place in all of 26 cases collected by Richard. Simple incision with subsequent packing is an unreliable procedure, because of the possibility of recurrence or prolonged suppuration. If the patient refuses to be operated upon or if there are counterindications, Esmarch's method of puncturing and subsequent injection of iodine (Lugol's solution) may be tried. A permanent cure has occasionally followed this method of treatment.

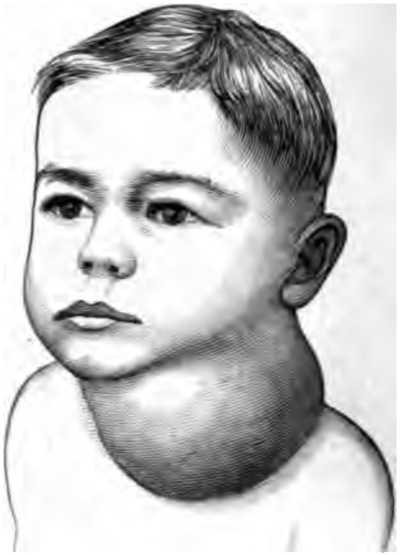
Branchiogenic Abscesses.—The cyst contents may become purulent owing to local infection or infection through the blood. The branchiogenic nature of such abscesses can only be proved by demonstrating the characteristic epithelium of the abscess-wall.

Branchiogenic Tumors.—Complicated tumors arise from simple cysts by proliferation of the epithelium or of the connective tissue. In any individual case it may be very difficult to determine the origin. Adenomatous new growths may develop from the glandular epithelium (cystadenoma), and lymphangioma may arise from overgrowth of lymphoid tissue, or by combination lymphangio-adenocystoma. Finally malignant degeneration of the epithelium may take place, giving rise to so-called branchiogenic carcinoma.

Congenital Serous Cysts.—These tumors develop by continual dilatation of the lymphatic vessels, as demonstrated by Köster in 1872, and later by Winiwarter and Wegner. They were called lymphangiectasia congenita (Köster) or lymphangioma cystoides (Wegner). The tumor consists of multiple cysts lined with endothelium, and contains a clear serous fluid that coagulates on standing. When the fluid is brownish, there is generally blood mixed with it. Sometimes the fluid is "milky." A cross-section shows a series of larger and smaller cavities lying close to each other with openings varying from the size of a walnut to that of the head of a pin. The individual cavities are irregular with secondary cavities or prominent bands and partitions. Often no communication between the individual cavities can be made out. The smaller the cysts, the more numerous their mutual communications, so that their general appearance may resemble that of cavernous lymphangioma. Köster was able to trace the connection of these cavernous portions with lymph-vessels and glands. When the cysts are well developed, the communications with lymph-vessels proper are limited, thereby differing from cavernous lymphangioma. The dilated lymph-spaces have become more circumscribed, and may reach the size of an orange, being loosely connected with the neighboring tissues. The wall of the cyst is smooth. The intervening tissue between the individual cysts is usually thin; occasionally it may be reinforced by more pronounced proliferation of connective tissue and fat.

The tumor is generally found in the subcutaneous tissue and may be traced inward. Some are primary in the deep connective tissue, especially in that of the carotid sheath, and then grow toward the surface. The prolongations of the tumor extend between all the organs and tissues of the neck, between the œsophagus and trachea into the mediastinum, between the muscles of the vertebral column, surround the large vessels, and finally encroach upon the pharynx and cavity of the mouth. There is, as a rule, no distinct connective-tissue capsule, the absence of which may give rise to considerable trouble when trying to excise the mass. Contrary to malignant tumors, the surrounding tissues are not involved by the cystic new growth, although atrophy of muscles, due to overstretching and pressure, is quite common. As a rule these cysts develop in the upper part of the neck, in the nape of the neck, more rarely in the supraclavicular fossa or in the upper triangle. The seat of election is the anterior or posterior border of the sternomastoid at about the level of the margin of the jaw. (Fig. 38.)

FIG. 38.



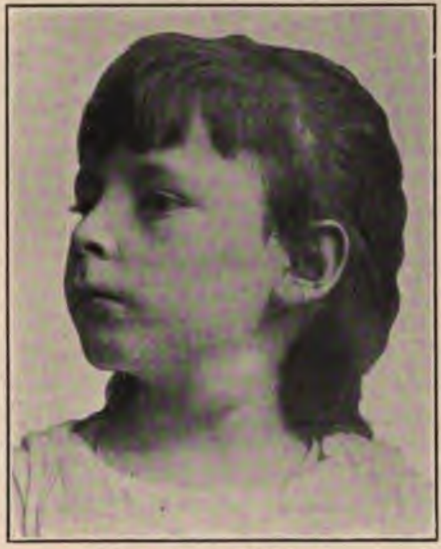
Congenital cystic hygroma (cystic lymphangioma). (v. Bruns.)

Clinically there will be found a distinctly fluctuating tumor under slight tension with smooth or slightly nodular surface. The overlying skin is movable, and often so thin on account of stretching that the underlying portion of the tumor seems transparent. Sometimes, however, the skin may be thickened because it is involved in the process. The superficial veins are dilated when the growth is very extensive. Firm fibres are often felt between different portions of the cyst. These are either thick septa or surrounded structures, such as muscles, for instance. The tumor is not compressible and shows no tendency to change in size, a condition explained by the very limited connection of cystic spaces with larger lymph-vessels.

The growth is very slow. The size at birth may vary considerably. Inside of a few months the entire half of the neck from the jaw to the collar bone and from the nape to the middle line may be affected. When the tumor is as large as this, disturbances of respiration and nutrition due to pressure on the œsophagus or pushing up of the tongue have been reported. Even without such complications the children sometimes become emaciated and die of inanition. Entrance of micro-organisms through excoriations of the skin not infrequently leads to inflammation and suppuration of the contents.

DIAGNOSIS.—The diagnosis is as a rule easy. In the differential diagnosis congenital branchial cysts must be considered. They are characterized by their position, and may be definitely diagnosticated by exploratory puncture. When the serous cyst develops primarily in the deep-seated layers of connective tissue, it is possible to confound it with lipoma as long as the tumor does not reach the surface. The absence of compressibility will guard against mistaking for cavernous tumors.

FIG. 39.



Dermoid cyst of the neck.

PROGNOSIS.—The prognosis, in spite of the benign nature of the tumor, is unfavorable, for it is uncommon to have the growth remain stationary or to have recovery take place spontaneously by rupture of the sac. The outlook may become more favorable under treatment, and recently repeated recoveries after operative interference have been reported.

TREATMENT.—Radical excision is difficult on account of the size of the tumor, and is not without danger because of the age of the patient. In a child one year of age in whom palliative treatment had been without result, the author was able to remove a tumor the size of a fist through a flap-incision after exposure of the large vascular trunks and nerves down to the vertebral column. The wound healed by first intention. Considering the great danger associated with operative interference, it is justifiable in any case first to try bloodless methods, such as puncture with subsequent injection of dilute solutions of iodine, especially since recoveries have been repeatedly reported after this procedure. If such an attempt is unsuccessful, operation is indicated. If an operation is counterindicated because of the condition of the child, there remains to be tried incision with subsequent antiseptic packing, a procedure less reliable. (Wölfler.)

Subcutaneous Dermoid Cysts.—These occur more rarely in the neck than on the head, and are usually situated in the region of the branchial clefts. They frequently do not attain considerable size until adult life. Eventually they do not as a rule exceed the size of a walnut and grow very slowly.

DIAGNOSIS.—The diagnosis between soft hyperplastic lymphoma and gland abscesses is at times very difficult.

TREATMENT.—Excision is easy and can usually be done with local anæsthesia.

Blood-cysts.—Blood-cysts are cystic tumors, the contents of which consist of pure fluid, usually venous blood. The etiology of these tumors is not uniform. The following modes of origin are to be mentioned, although histological investigations are as yet few: 1, the cysts may be due to fœtal malformation; 2, they may develop from branchial cleft cysts; 3, they may be due to partial ectasy of veins; 4, they may be the result of a cavernous angioma; and 5, they may arise from a lymphangioma.

1. The cyst is at times found where a vein ought to be, and owes its origin to some disturbance of development in this region in early fœtal life. Thus in a case reported by Koch in a child one and a half years of age, three large cysts filled with blood were found where the subclavian vein ordinarily is. These tumors occupied the supraclavicular fossa, the posterior mediastinum, and the larger part of the right pleural cavity. In a case reported by Hüter, Bajardi, and Borman, the sac occupied the position of the internal jugular vein. In a second case mentioned by Borman the cysts were below the angle of the jaw, in the region of the facial vein. Deschin reports a case in which the external jugular vein emptied into a sac, and Volkmann found the common jugular vein above the clavicle distended to the size of a goose's egg, while the upper half of the vessel was completely absent.

2. In Gluck's case the cyst consisted of a sac lined with several layers of cylindrical epithelium like that of a branchial cyst. The tumor was connected with the common jugular vein by a wide communication. This was probably due to rupture of the vessel-wall, owing to pressure of the cyst. The wall of branchial cysts has frequently been observed to be very vascular, and the possibility of blood-cysts developing from these should not be overlooked.

3. Langenbeck's observations would seem to indicate that blood-

cysts may arise from varicose widening of a vein and subsequent obliteration of the trunk.

4. Franke decided that a blood-cyst which he excised arose from a deep-seated cavernous angioma. He based his conclusion on the microscopical examination of the specimen.

5. In a case reported by Weil, the cysts were due to hemorrhage from the vascular wall into a cystic angioma. This mode of development is supported by the observation frequently made that the first puncture oftentimes shows serous fluid, whereas later the contents are bloody.

Microscopical investigations show that the cyst-wall resembles more or less that of a vein. The inner surface is frequently crossed by bands and resembles the inner surface of an auricle. Elastic tissue and smooth muscle-fibres are abundant, whereas endothelium is found only in places. In Volkmann's case the cyst-wall consisted of cavernous tissue with meshes, while the inner surface had shallow pockets. In Gluck's case the cyst had several layers of epithelium and resembled a branchial cyst.

SYMPTOMS.—The tumors are either congenital or occur later in life (up to fifty years). Of 31 cases collected by Taylor, 9 were congenital. Both sexes are equally affected. The left side of the neck, according to the statistics, is more frequently the seat of this disturbance. The size varies from that of a walnut to that of a child's head. Frequently the entire side of the neck is occupied by the tumor. In other cases the growth may be situated below the sternomastoid or just above the clavicle, and may extend to the axilla or over the anterior surface of the thorax. The overlying skin is normal and movable. The tumor itself is usually movable, often round, smooth, or slightly nodular. The consistence is elastic and fluctuating. The growth does not pulsate. Cysts communicating with larger veins may be diminished in size by pressure or made to disappear entirely, but reappear immediately after removal of the pressure. The tension in the tumor increases when the expiratory pressure is increased (coughing, crying). Discomfort is only produced when the cysts increase greatly in size and push aside or press upon neighboring organs. Difficulty in swallowing and breathing and neuralgic pains are frequently observed in the region of the branchial plexus. The tumor may develop rapidly or very slowly, or the cyst may remain stationary for a considerable time.

DIAGNOSIS.—The diagnosis in cases in which cysts communicate with larger veins is easy if the above-mentioned symptoms are present, but more difficult when the cysts are independent or secondary to some other type of cyst. In the differential diagnosis there should be considered aneurism, cavernous angioma, lipoma, thyroid cyst, cold abscess, and finally pseudofluctuating malignant tumors. Blood-cysts differ from aneurisms chiefly by the absence of pulsation. Exploratory puncture alone will exclude the remaining diseases mentioned. The fluid venous blood and microscopical examination will decide the diagnosis.

PROGNOSIS.—The prognosis, generally speaking, is favorable, for complications dangerous to life on account of excessive growth of the tumor rarely arise.

TREATMENT.—Three methods of removing the cyst are to be mentioned: compression, injection of iodine, and excision.

Compression by means of flannel or rubber bandages may be tried, especially in childhood. Kaczanowsky has recently reported a brilliant cure in a child four months of age. A large blood-cyst completely disappeared within a few months as a result of compression.

Repeated complete and permanent recovery has followed injection of iodine. Disastrous results have also been reported as a result of the iodine entering the circulation. This procedure should therefore only be used in cysts that do not communicate with the vessels. However, as the diagnosis of the kind of tumor present is at times impossible, it is advisable to use injections of iodine only in a limited number of cases. The strength of the tincture of iodine used is 1 part in 5. Eighty minims of this are injected into the sac at intervals of one or more days. Preliminary puncture is not necessary. In the Erlanger clinic a tumor the size of a man's fist that had grown in the supraclavicular fossa within eight days in a boy nine years of age was made to disappear rapidly by this method.

The most desirable method of treatment is radical excision, the dangers of which have been considerably diminished owing to the advances in the treatment of wounds and operative technic. When the sac is large, this procedure is very difficult, because injury to large veins is oftentimes not to be avoided. The value of large incisions, exposure of the vessels at the lower end of the sac, and a provisional ligature should not be forgotten. The latter can always be tightened by an assistant in case of hemorrhage.

Acquired Cysts.—Sebaceous Cysts of the Skin.—These may develop in any region of the neck. They are characterized by their relation to the skin, their slow benign growth, and their remaining stationary for years, so that a diagnosis is usually easy. In the submaxillary and submental regions there may be difficulty in distinguishing between hyperplastic, softened, or broken-down glands that have become adherent to the skin. Treatment is excision.

Cystic Bursæ of the Thyrohyoid Region.—In the region of the hyoid bone are three bursæ that may undergo cystic change: 1. The subhyoid bursa, which is constant and situated between the thyrohyoid membrane and the body of the hyoid bone. It will be found between the posterior surface of the bone and the insertion of this ligament along its upper margin. The bursa is irregular in shape, varies in size, and often extends to the upper margin of the thyroid cartilage. It has sometimes several compartments or may be divided by a septum into two chambers. 2. At the notch of the thyroid cartilage immediately over the perichondrium, and covered superficially by fascia, there is found the subfascial prelaryngeal bursa. This is not constant, is seen in children, and seems to develop gradually with the increase in size of the thyroid cartilage. 3. In rare cases a bursa is found above the hyoid bone between the posterior insertion of the geniohyoid and genioglossi. This is the suprahyoid bursa. Mechanical irritation or rheumatism may lead to serous or fibrinous hydrops, most frequently in the bursa subhyoidea.

SYMPTOMS.—A tumor rarely exceeding the size of a walnut develops slowly and without producing discomfort in the region of the hyoid bone. It is rounded, smooth, fluctuating, accompanies the movements of the thyroid on swallowing, has a fixed base, and is covered with normal skin. It is usually painless, and annoys only from a cosmetic standpoint. In a few cases suppuration has been observed following pyogenic infection.

DIAGNOSIS.—An accurate diagnosis can hardly ever be made clinically because branchiogenic cysts are observed in the same region (ductus thyroglossus). Cysts of secondary thyroid glands and cysts of the suprahyoid gland described by Zuckerkandl present the same picture and occur also in this region. Microscopical examination of the cyst-wall will enable a correct diagnosis.

TREATMENT.—The tumor may be excised except when there are special reasons for avoiding a scar. Puncture and subsequent injection of iodine may then be tried.

Echinococcus Cysts of the Neck.—Echinococci are rarely found in the tissues of the neck. Of 196 cases reported, only 2 were in the neck—1.02 per cent. Only 9 of 101 cases collected by v. Bergmann were situated in the neck. The statistics collected by Güterbock in 1893 include 26 cases of the neck.

SYMPTOMS.—In the majority of cases the cysts develop below the sternomastoid in the connective tissue surrounding the large vessels. The muscles are somewhat displaced, and when the growth is of considerable size it may appear at the outer margin of the sternomastoid and sometimes at the inner, so that a saddlebag-like tumor develops. A characteristic symptom to which attention has been called by v. Bergmann is the sudden periodic increase in size of the tumor, followed by a period of inactivity. In the course of years the mass may occupy one-half of the neck, reaching from the vertebral column into the chest. Pressure-symptoms, such as neuralgia and obliteration of vessels, gradually make their appearance. Erosion of the vessels with fatal hemorrhage was observed in 3 cases after incision of the sac. The surface of the tumor is smooth or slightly nodular. The mass fluctuates distinctly, although this may be difficult to ascertain on account of the deep position in the neck. When the contents are not cloudy, the tumor may be translucent. A hydatid thrill has seldom been noted. Inflammatory changes and suppuration of the cyst contents are not uncommon.

DIAGNOSIS.—The diagnosis is often impossible, and in the majority of cases is made on operation. The growth is confounded with other cystic tumors, abscesses of glands, and even with lipoma. Exploratory puncture is often negative, owing to the absence of hooklets in the cystic contents.

Rarely the echinococcus is situated in the sternomastoid itself and forms a circumscribed cystic tumor in the substance of the muscle. This localization was present 4 times in the 26 cases mentioned above. In a patient of Güterbock's the picture was that of acute glandular abscess over the sternomastoid on account of suppuration of the cyst contents. A correct diagnosis was made only after microscopical examination of the abscess membrane.

PROGNOSIS.—The prognosis is generally favorable, and recovery almost always follows appropriate treatment.

TREATMENT.—Three methods are to be considered: puncture with subsequent injection of iodine, incision with packing, and radical excision. Puncture with subsequent injection of iodine has been performed 4 times followed by complete recovery in 2 of the cases. Incision with packing was followed by recovery in 10 of 14 cases, whereas in 4 death was due to secondary hemorrhage from eroded vessels. The results of excision are the most favorable. The result was perfect in 6 cases operated upon in this way. Removal of the entire sac is without doubt the safest way to treat the condition. This should always be done with small and medium-sized tumors. Unusual size and extensive adhesions increase the danger of the operation considerably and form the only contraindication to excision. In these cases incision and packing are to be preferred.

Vascular Tumors of the Neck.

Hemangioma.—Angioma Simplex.—This form may spread over the surface or be subcutaneous, and may be found in any part of the neck, although the region of embryological fissures is the seat of election (fissural angiomas). The growth is removed by excision or ignipuncture.

Cavernous Angioma.—Cavernous angiomata occur in two forms, either superficial or deep. Both are rarely congenital, develop usually during adult life, and may arise from simple angiomas. In a number of the cases they possess a connective-tissue capsule, while [illegible]. They are either connected with the veins [illegible] causes the tumor to pulsate [illegible] by pressure, and [illegible] its previous [illegible]. The size of the [illegible] becoming at the [illegible] are of especial [illegible] only possible [illegible] detection [illegible] of this variety [illegible] observa- [illegible] case of his own. [illegible] fossa in the [illegible] the neck. The tumor is situated below the fascia, and usually below the sternomastoid. In a case operated upon by Israel the angioma developed near the spinal column in the vicinity of the rectus capitus anticus major, and extended toward the pharynx and the region of the angle of the jaw. The vagus and sympathetic were displaced forward, and the latter was so flattened and adherent that it was resected. Angiomata have repeatedly been connected with large veins, even with the internal jugular itself. In operating upon a cavernous angioma the size of a goose egg between the jaw and the anterior margin of the sternomastoid, Eisenreiter was obliged to tie three veins each the size of a pencil.

SYMPTOMS.—Angiomata develop slowly as a rule, but at times the growth is extremely rapid, finally giving rise to large tumors occupying the entire half of the neck. These may cause disturbances by pressing on the trachea and œsophagus. The method of extension corresponds to that of subfascial lipoma, with which they are frequently confounded.

PROGNOSIS.—The prognosis is doubtful when the tumor is extensive, although it is benign. Recovery may follow proper surgical interference even when the mass is extensive.

TREATMENT.—Excision may at times be difficult on account of the intimate connection with large vessels and nerves. Of 12 cases reported by Eisenreiter the mass was excised 4 times with 3 permanent results. The bloodless methods, such as ignipuncture, electrolysis, injection of ferric chloride or carbolic acid, are not to be recommended when the growth is deep-seated.

Aneurism. (See page 66.)

Lymphangioma Cavernosum.—This variety of tumor has been observed but twice in adults, in the supraclavicular fossa. In a case operated on by Langenbeck, a tumor about the size of a fist had gradually developed during two years in a laborer twenty-five years of age. It was soft, somewhat compressible, and indistinctly fluctuating in places. The prominent portion was adherent to the skin. At the operation milky fluid escaped from the cystic spaces. It was intimately connected with the jugular and subclavian veins, but could be separated without much difficulty. There were also adhesions to the omohyoid and sternocleidomastoid. A prolongation of the growth extending below the sternum into the mediastinum consisted of numerous small cysts. This could be completely removed by careful traction. Permanent recovery. König was able to remove completely, by blunt dissection, a lymphangioma of the supraclavicular region. This angioma extended between the muscles and vessels deep into the neck, and consisted of about thirty small cysts that were situated around a branch of the inferior thyroid artery.

Diagnosis.—The clinical diagnosis is difficult, as it is often not possible to avoid confounding with lipoma and cavernous aneurism.

Treatment.—The treatment is excision, which is more apt to be followed by complete recovery than injection.

Solid Tumors of the Neck.

Fibromata.—These are divided, according to their seat, into superficial and deep fibromata. The superficial variety, developing in the skin and subcutaneous connective tissue, represents a type of congenital elephantiasis. As in every other region of the body, fibroma molluscum in the neck is cutaneous or subcutaneous, and takes its origin either from the sheaths of the cutaneous nerves (neurofibroma, v. Recklinghausen), or from the bloodvessels, more particularly from the capillaries with thickened walls (angiofibroma, Jordan). Besides the circumscribed type, there may be diffuse fibromatosis or elephantiasis, characterized by thickened folds of skin overlapping each other and separated by transverse sulci. In the neck the condition is usually combined with multiple neuromata. In the latter case round strands can often be felt in the subcutaneous tissue with spindle-shaped or nodular swellings. On examination these prove to be nerves thickened by proliferation of connective tissue.

Deep-seated fibromata are found not only in the nape of the neck, but also in the lateral and anterior regions. Fibromata of the nape of the neck usually develop from the aponeurosis (Guyon), rarely from the periosteum of the vertebræ. They form solid smooth tumors that reach the size of a child's head and extend from the occiput to the interscapular region. In the lateral region of the neck the tumors are situated beneath the sternomastoid, developing from the connective-tissue sheaths of the large vessels and nerves. In a case observed by Lebert and Niehans each cervical ganglion of the sympathetic was the seat of a neoplasm. Falck considered the perimuscular connective tissue of the longus colli muscle to be the primary seat of a tumor occupying the entire half of the neck and situated beneath the sternomastoid. Fibromata in the anterior region of the neck are uncommon, and are represented but twice in the statistics of de Quérvain containing 25 cases. In a patient operated upon by Middlemist a tumor the size of an egg, lying between the angle of the jaw and the anterior margin of the sternomastoid took its origin from the sheath of the carotid, whereas in de Quérvain's case a tumor of about the same size, between the submaxillary region and the larynx, was connected by a peduncle with the fascia of one of the muscles of the tongue.

Fibromata grow very slowly and often remain stationary for a considerable time, but may eventually become extensive and give rise to considerable annoyance by pressing upon or displacing neighboring organs. Several times dyspnœa to the point of suffocation, difficulty in swallowing, and radiating neuralgic pains have been reported. In the advanced stages secondary adhesions form to the vertebræ, the clavicle, and to the large vessels.

Diagnosis.—The diagnosis is easy, as a rule. The solid consistence will prevent confounding with deep-seated lipoma, and the slow growth will prevent mistaking for sarcoma.

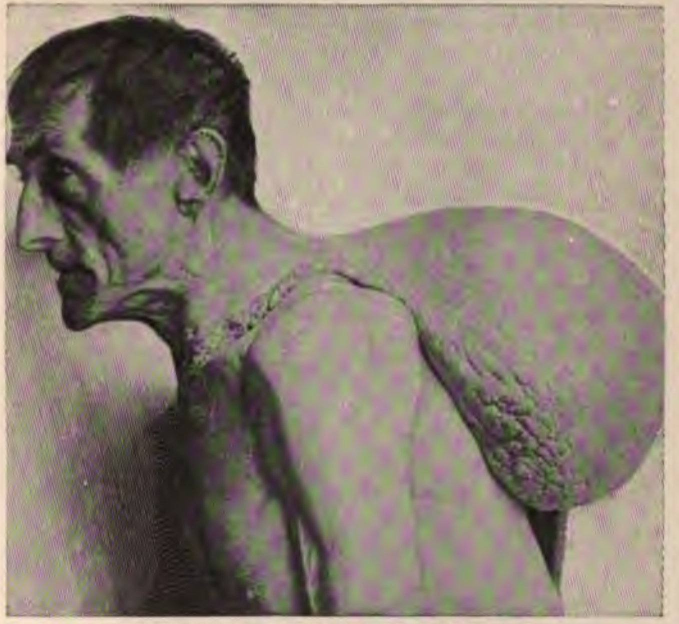
Prognosis.—The prognosis is favorable.

Treatment.—The treatment consists in excision, which is easier the sooner it is undertaken. In advanced cases adhesions may make the operation difficult. Resection of the jugular vein has several times been necessary. Fibrous masses in the skin are best removed at several sittings. Elliptical incisions are made around the individual folds.

Lipomata.—Their seat of election is the back of the neck, where they may be found at any time of life. They are divided according to their seat and extent into subcutaneous, subfascial, and circumscribed or diffuse.

The circumscribed variety is characterized by sharp outline and connective-tissue capsule. The subcutaneous tumors are usually seated in the nape of the neck, and may be symmetrical. They vary in extent, and in rare cases may form colossal appendices reaching down on to the back. (Fig. 40.) In the anterior region of the neck widely differing types of this tumor are found; Gold described a lipoma weighing twenty-six pounds that hung down from a thick, broad pedicle like a sac and covered almost the entire surface of the trunk.

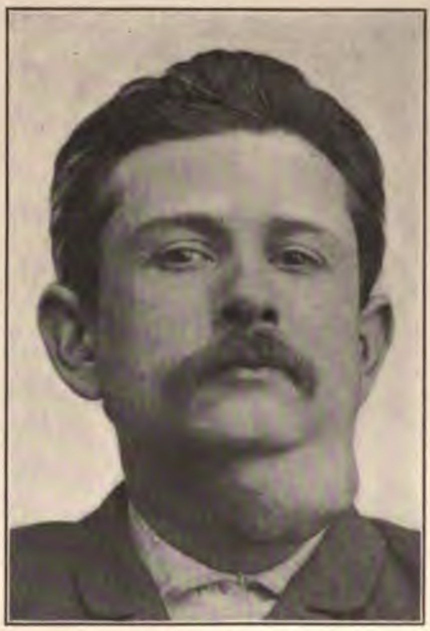
FIG. 40.



Circumscribed lipoma of the nape of the neck.

Subfascial deep lipoma is comparatively rare. Plettner in 1889 was able to collect but 15 observations from current literature. Klaussner has recently reported a typical case. The tumor is quite frequently congenital, and is therefore noticed more often in children; but it may develop later in life. It is always encapsulated, burrows between the muscles, also between the large vessels and nerve-trunks, and may even surround the œsophagus and trachea. In almost all of the cases the tumor was in relation with the sheath of the vessels, and was frequently intimately adherent to the internal jugular vein (Langenbeck's lipoma of the vessel-sheaths). As far as its distribution is concerned, subfascial lipoma is somewhat similar to malignant tumors, but differs from these by the absence of adhesions. The prolongations extending in between the neighboring structures may usually be shelled out by blunt dissection. A lipoma may be in the anterior region of the neck, covering the trachea and larynx, and pushing the sternomastoid to one side; or it may be in the lateral region of the neck—*i. e.*, the space between the larynx and the sternomastoid; and finally it may be situated in the supraclavicular fossa with prolongations reaching down between the cords of the brachial plexus into the axilla. Subfascial lipomata also differ from the subcutaneous variety in that they are usually of irregular shape, which may in part be due to the resistance of overlying fascia and muscles. In Klaussner's case the lipoma hung down like a sack at the side of the neck. This flap-like appearance is not so marked as in the subcutaneous variety. The overlying skin is normal and can be lifted off in folds. Enlargement takes place slowly. Only when of extreme size do disturbing symptoms arise, chiefly due to compression of the œsophagus and trachea.

FIG. 41.

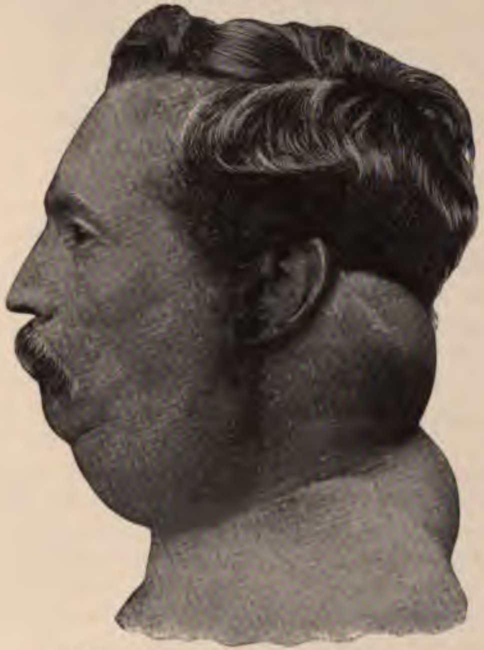


Lipoma of the neck.

With supraclavicular tumors neuralgic pains at times follow pressure upon the plexus.

Diffuse lipoma is a rare disease, and occurs exclusively in middle-aged men. The 33 cases collected by Madelung in 1888 were in men of the working-class that were otherwise healthy and showed no particular tendency to general obesity. When the tumor is very pronounced, the neck is surrounded by masses of fat, collar-like, that are somewhat more prominent in certain places. If the disease is more circumscribed, individual tumors may be made out. (Fig. 41.) In the upper region of the neck below the superior curved line a hemispherical fatty mass will be found on either side separated by a depression corresponding to the ligamentum nuchæ. Below this there is usually a uniform roll of fat across the median line in the region of the lower cervical and upper dorsal vertebræ. This is separated from the upper masses by a transverse depression corresponding to the sixth vertebra. In the anterior and lateral regions of the neck there are sometimes masses of fat separated by a median depression and forming a sort of double chin which extends back to the region of the parotid and mastoid and downward as far as the sternum. Accumulation of fat in the supraclavicular fossa is not uncommon. Lipoma is primary in the subcutaneous tissue, but may extend through the fascia to the deeper regions, so that the fat finally infiltrates the muscles and sur-

FIG. 42



Diffuse lipoma of the neck. (v. Bruns.)

rounds the vessels, œsophagus, and trachea. It is usually diffuse, but there is no tendency to the formation of folds.

The disease is of importance chiefly from a cosmetic standpoint; disturbances arise only when the growth is of extreme size and presses upon the trachea or œsophagus, as was the case in one of Madelung's patients.

Etiology.—The etiology of the disturbance is unknown. It is interesting, however, that one or both lobes of the thyroid gland have been observed to be absent.

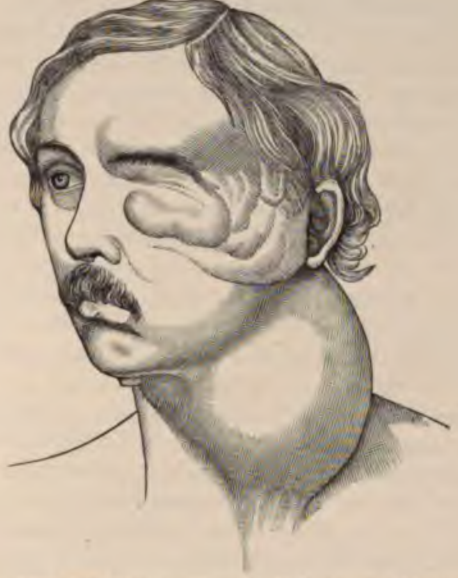
Diagnosis.—The clinical picture of diffuse as well as of subcutaneous circumscribed lipoma is so characteristic that the diagnosis of these cases is hardly ever doubtful. On the other hand, the diagnosis of subfascial lipoma is oftentimes difficult, and may even be impossible, for the characteristics of lipoma are oftentimes absent on account of the deep location of the tumor. It may be confounded with goitre, cysts, abscesses, soft malignant tumors, or deep-seated cavernous aneurisms.

Treatment.—In the encapsulated subcutaneous and subfascial types of lipoma excision is usually easy even when the size of the tumor is great, because, as already mentioned, the prolongations into surrounding regions can generally be separated by blunt dissection. The removal of a diffuse lipoma of the neck, on the other hand, is a difficult task, because separation of the masses of fat from the skin and fascia requires the utmost care on account of the absence of any marked boundary. The danger of infection even with present methods of treating wounds is not to be disregarded, because of the extent of the wound surface. As a rule, the operation has to be interrupted and divided into several sittings, so that a partial result at a time is all that can be obtained. Preyss in v. Bruns' clinic has recently reported several successful cases of radical excision performed at repeated sittings. It is justifiable to make an attempt to diminish the size of the tumor by injections of ether or alcohol. Löwenthal has recently reported a complete cure of a lipoma of the back of the neck treated in this way: forty-two injections of ether or alcohol (15 minims each) resulted in shrinkage of the tumor to a small cartilage-like mass.

Neuroma.—"Rankenneurom," or fibroma molluscum, is most frequently found in the lateral region of the neck, in front or behind the ear, and rarely extends down on to the neck or is primary in this region. Of 42 cases collected by v. Bruns, the lateral region of the neck was involved but 4 times and the nape of the neck 3 times. As mentioned in connection with fibroma, the fibromatosis occurring in circumscribed areas involving the nerves of the skin and subcutaneous tissue is usually associated with elephantiasis, pigmentation, and often abnormal growth of hair in the overlying skin. The superficial position of the tumor renders excision neither difficult nor dangerous.

In rare cases isolated or multiple fibroneuroma are observed in deep-seated nerves, such as branches of the cervical and brachial plexus, the sympathetic or the vagus, and may give rise to symptoms of irritation or paralysis. The accompanying illustration (Fig. 43) represents a neuroma of the vagus the size of a fist with multiple neuroma of the trunk and Rankenneuroma of the temple.

FIG. 43.



Neuroma of the vagus and "Rankenneuroma" in the temporal region. (v. Bruns.)

Enchondroma and Osteoma.—Aside from congenital small cartilaginous growths situated in cutaneous appendices, bony or cartilaginous formations may take their origin from the cervical vertebræ, the clavicle, the sternum, or the first rib. They will be considered in other chapters of this work.

Primary Sarcoma.—The majority of sarcomata are primary in the lymph-glands, and are therefore lymphosarcoma. As in other regions of the body, so in the neck, a pigmented nævus of the skin may at times be the primary seat of sarcoma. The periosteum of neighboring bones, such as a vertebra, a collar bone, the sternum, or first rib, may be the seat of primary sarcoma.

Malignant Tumors of the Vessel-sheaths. (v. Langenbeck.)—It is no longer justifiable to give these tumors any special place. Both cases of carcinoma described by Langenbeck, which were supposed to develop from lymphatic structures of the vessel-sheaths, belong in all probability to the branchiogenic carcinoma, the relation of which to the sheaths of the vessels is quite characteristic. Sarcomata of the sheath are in all probability lymphosarcomata (sarcomata of the lymph-glands) that have become adherent to the vessel-sheaths quite early. Whether these are true sarcomata arising from the connective-tissue sheaths of the vessel is doubtful, and has not been definitely proved because histological differentiation is not possible. Inasmuch as the relation of the tumors to vascular sheaths is probably secondary in the majority of cases, and as they do not show any histological characteristics of one or the other kind of tumor, it seems justifiable to drop a name representing only accidental topographical relations.

Primary Carcimona of the Neck.—This neoplasm is observed in the skin and also in the underlying tissue. Carcinomata of the skin are extremely rare, and develop at times in old scars due to suppuration of tuberculous glands. The treatment consists in early radical excision.

Deep-seated carcinomata are usually situated in the upper triangle, and correspond in structure to carcinomata of the skin. Volkmann assumed that they arose from epithelial foci remaining during the retrograde changes of the branchial clefts, because squamous epithelium does not normally occur where these growths are primary. He described 3 cases in 1882, and called these carcinoma branchiogenic or branchial. The correctness of this view is supported by the fact that it has been repeatedly demonstrated that carcinoma may develop from the epithelium of branchial cysts and by the topographical distribution of the growths.

As a rule the tumor is situated in the upper triangle of the neck, occupying the space between the larynx, hyoid bone, and sternomastoid, under the anterior margin of which they extend backward. They are situated beneath the cervical aponeurosis and are quite frequently intimately adherent to the large vessels, the vagus, and the sympathetic. The situation therefore of the growth corresponds to the accepted location of the second branchial cleft, the sinus cervicalis, and the relation to the vessels is explained by the course of branchial fistulæ that follow along the carotid upward. In individual cases the neoplasm was situated in the middle and lower anterior region of the neck.

In a man fifty-seven years of age who had noticed for one-half year a small mass develop in the upper triangle of the neck, at the operation a hollow space extending inward, with dense proliferating walls, was found between the hyoid bone and the great vessels. Microscopical examination showed squamous epithelial carcinoma. (v. Bruns.) In a second case, also treated by Bruns, a cystic tumor that had developed within five months at the seat of bifurcation of the carotids, was found on puncture to contain abundant yellow cloudy fluid with epithelial cells. On incision the internal surface was found to be papillary, and the microscopical examination showed squamous epithelial carcinoma with papillæ in the external connective tissue of the wall. (Richard.)

A cyst existing since youth suddenly suppurated and after incision a sinus was left leading to a persistent small tumor. The latter increased [illegible] year after [illegible], became firm, and was shown [illegible] (Bruns and Richard.)

[illegible] a tumor that developed in five [illegible] (Quarrey-Silcock.) [illegible] papillary tissue, and micro- [illegible]

The inner surface of a cyst situated in the lower third of the sternomastoid in a man thirty-two years of age was shown to have undergone carcinomatous degeneration. (Quarrey-Silcock.)

The cases of branchiogenic carcinoma reported are few. Besides the above-mentioned 8 cases, there are 8 more mentioned by Gussenbauer, 1 by Reverdin and Mayor, 1 by Eigenbrodt, and in all probability the 2 cases of tumor of the vessel-sheaths described by Langenbeck, and the case of squamous epithelial carcinoma at the seat of division of the carotids, published by Regnault, are to be included in this group. In the spring of 1898 the author made one further observation in a man fairly advanced in years. A tumor developed in the left superior triangle of the neck. This growth presented all the characteristics of a branchiogenic carcinoma. The neoplasm was excised after resection of the internal jugular vein and the external carotid. The microscopical examination showed squamous epithelial carcinoma. The patient died two months later of recurrence with metastasis. The autopsy corroborated the diagnosis.

Symptoms.—All cases so far reported were in men, and almost exclusively in men fairly advanced in years, forty to sixty-five. The disease is more frequent on the right side of the neck than the left. A nodule develops in the typical situation, increases at first slowly without causing discomfort, but sometimes after a few months enlarges more rapidly and then gives rise to neuralgic pain. The latter radiates especially to the region of the occiput and ear, and may become so intense that the patient is deprived of sleep. Quite frequently the patient's attention is attracted to the growth by this pain; the tumor itself being deep-seated and only slightly noticeable. During the subsequent course a nodular and very firm mass, covered with normal skin, becomes noticeable in the upper triangle of the neck. It is situated beneath the sternomastoid, and is closely adherent to this muscle and to the underlying tissues. Pulsation of the carotids may at times be felt at the upper and lower margins. The glands in the vicinity are infiltrated, the tumor involves the entire half of the neck, becomes adherent to the skin and ruptures externally, giving rise to suppuration and hemorrhage. In other cases large vessels are broken into, especially the internal jugular. This event may be followed by metastases in the internal organs. These or local complications lead to a fatal termination. The course of the disease is rapid, lasting at the utmost from one-half to a year and a half.

Diagnosis.—The diagnosis is difficult, and can be made absolutely only from the subsequent history after excision of the carcinoma or on autopsy. A clinical provisional diagnosis is usually based on the presence of a tumor corresponding in its nature to carcinoma and found in the characteristic position beneath the fascia. Secondary origin of the mass must, of course, be excluded. In doing this, however, it must be remembered that there are carcinomata in hidden places, such as the nose, the larynx, and œsophagus, that are very hard to find, whereas secondarily enlarged glands are quite in evidence. Secondary glandular carcinoma frequently differs in the early stages from branchiogenic carcinoma in that it is apt to remain for a time painless, circumscribed, and movable, whereas branchiogenic carcinoma in the early stages is intimately united to the large vessels and nerves and to the sternomastoid, and is early associated with pain.

The histological structure of both is identical, so that microscopical examination of excised nodules only gives definite information when glandular tissue can be found in the carcinoma.

In a case referred to the author's clinic a tumor the size of an apple situated in the typical position was taken for a branchiogenic carcinoma. The diagnosis, however, was in doubt because a good view of the larynx could not be obtained on account of œdema. Microscopical examination of the excise growth showed squamous epithelial carcinoma with typical lymph-follicles. On the strength of this information it was assumed to be a metastatic carcinoma of the glands, and later laryngoscopic examination showed the presence of carcinoma of the larynx.

Aside from secondary glandular carcinoma, cancer of the supernumerary lateral lobes of the thyroid gland, although uncommon, must be considered in the differential diagnosis. These correspond topographically and in their clinical history to branchiogenic carcinoma. This type of tumor, an example of which has been recently reported by Berger, is only to be recognized by histological examination.

Under certain conditions non-carcinomatous growths may be confounded with branchiogenic carcinomata. Among these are lymphosarcoma, tuberculous lymphoma, and actinomycosis. Sarcoma is usually soft; on the other hand, tuberculous glands may be very firm because of fibrous periadenitis, and as they are apt to occur isolated in advanced years, they may be suspected to be carcinomatous. In doubtful cases exploratory incision is indicated. In actinomycosis there will be the characteristic firm infiltrated areas and foci of softening, and the skin is involved at a much earlier period. Neuralgic pains in the above-mentioned diseases are seldom so pronounced as in carcinoma.

Prognosis.—The prognosis is hopeless, for only one permanent cure after radical excision has so far been reported. (Eigenbrodt.)

Treatment.—Considering the futility of any other treatment, operative interference should be undertaken as soon as possible. Operation even in the early stages of the disease is difficult on account of the relation of the tumor to the vessels and nerves. Important anatomical structures are involved, so that extensive exposure of the field of operation is absolutely necessary. It is therefore advisable to use flap or cross-incisions, as recommended by Bruns and Gussenbauer. The first incision is made parallel with the anterior margin of the sternomastoid; the second, from the middle of the chin diagonally and curved to the middle of the sternomastoid, and finally from this place to the acromial end of the clavicle. The sternomastoid is divided, and *the four* flaps turned back in different directions. If the muscle is involved in the tumor, it must be resected; if it is intact, it is sewed with catgut at the end of the operation. The incision recommended by de Quérvain is useful at times. This is made from the anterior margin of the sternomastoid down to the sternum, and from here in a sharp curve outward along the collar bone, dividing the sternomastoid about 1.5 cm. above its insertion, so as to retract it with the skin-flap. The large vessels may be surrounded at the lower end of the wound with a provisional ligature. On account of adhesions, the internal jugular vein must always be resected, and frequently the carotid. At times it is even necessary to remove a portion of the vagus or the sympathetic. Inasmuch as the vessels and nerves have been subjected to pressure by the tumor for a considerable length of time, the danger of resection is much diminished. (See chapter on Injuries.) Considering the severity of the operation and the age of the patient, the mortality is not high. Of 8 cases operated by Gussenbauer, only 1 died after operation as the result of ligation of the carotid. The chances of prolonged relief or permanent cure are slight. Only 1 case as yet, that of Eigenbrodt, presented at the Twenty-third Surgical Congress, was free from recurrence for more than two years. Two of Gussenbauer's cases died of recurrent growth five to eight weeks after discharge, and in the other patients discharged well, no report as to subsequent state of health is at hand. In many cases radical operation is counterindicated, and one must be satisfied to use palliative measures, such as curetting and cauterizing with zinc chloride, combined with symptomatic remedies.

MALFORMATIONS, INJURIES, AND DISEASES OF THE LARYNX AND TRACHEA.

THE introduction in 1858 of the laryngoscopic mirror in surgery of the larynx and trachea opened a new era, the successes of which far exceed even the hopes of those who introduced the instrument. Although the first publications of Czermak and Türck placed the value of this new method for the recognition of diseases of the larynx beyond question, v. Bruns was first to found a new branch of surgical treatment by successfully removing a polyp of the larynx per vias naturales. Local cocaine anæsthesia, introduced by Jelinek in 1884, was an unexpected advance in endolaryngeal work, as it diminished considerably the demands on the technic of the operator and enabled more extensive interference without prolonged preparation of the patient. The more independent laryngology became, the more treatment of diseases of the larynx has been made the border-region where surgery and laryngology meet in common work. Although the mirror has multiplied the indications for extralaryngeal interference in some directions and has increased the possibility of early aid by establishing an early diagnosis, still the surgeon gladly turns over to the sparing hand of the laryngologist many patients that formerly would have come under the knife.

In the following pages everything that is technically laryngological has been avoided as much as possible without hazarding a scientific representation of the surgery of this region.

The description of laryngoscopic technic and the normal picture in a mirror does not belong in this work. Only one point will be shortly considered, as it is of surgical importance in numerous diseases of the larynx. The picture shown in a mirror oftentimes does not correspond to the extent of the lesions, which will be easily understood if it be remembered that inspection furnishes only superficial pictures, and that a large portion of the surface seen is considerably foreshortened in the mirror. The deeper regions are normally more or less hidden, and may be still further obscured from vision by overlying pathological changes. This fact must always be borne in mind when deciding whether to operate or not. The method of examining the trachea without the use of a mirror, published by Kirstein in 1894 under the name "autoscopy," is based chiefly on the possibility of bringing the laryngeal and tracheal tube and the mouth in a straight line by using a specially constructed instrument that presses the base of the tongue forward and downward. According to the experiences in v. Bruns' clinic, this procedure is of undoubted value, especially in children, in whom the anatomical conditions render its use possible. It may be a valuable supplement to mirror examinations. Killian has advanced one step farther with direct bronchoscopy. Under cocaine anæsthesia he introduces a straight tube into a bronchus. Neudörfer endeavored to examine deep-seated portions of the trachea and the under surface of the larynx by introducing mirrors into a tracheotomy wound when present. Better results are obtained by direct tracheoscopy with straight tubes, as first practised by Schrötter, and especially by Pieniázek. Killian has still further developed the method and applied the name "bronchoscopia inferior."

CHAPTER IV.

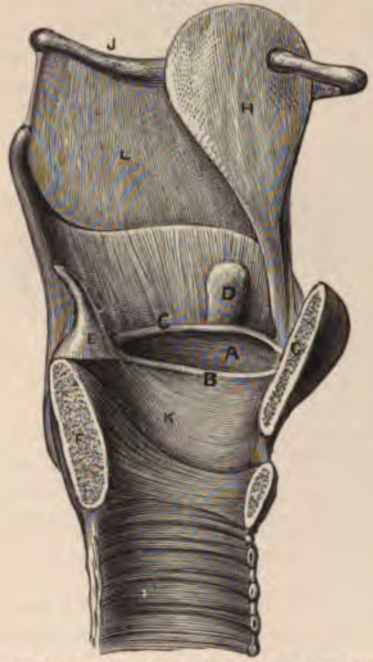
MALFORMATIONS OF THE LARYNX AND TRACHEA—LARYNGOCELE AND TRACHEOCELE.

Congenital malformations of the larynx and trachea are rare, and only those will be considered that are amenable to surgical treatment. The graver types (complete absence of the larynx, etc.), which are usually associated with other malformations, will not be considered, as viability is excluded.

MALFORMATIONS OF THE LARYNX.

It has been observed that disturbances in breathing in newborn infants are due to displacement of the epiglottis backward and abnormal kinking upward. In both cases reported by Schmidt and Refslund the entrance to the larynx was considerably constricted. Both children

Fig. 44.



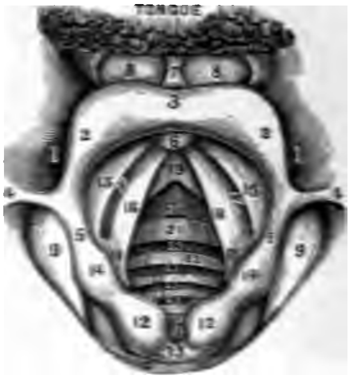
Vocal apparatus in a vertical section of the larynx: *A*, ventricle of the larynx; *B*, vocal cord; *C*, ventricular band; *D*, sacculus laryngis; *E*, arytenoid cartilage; *F*, cricoid cartilage; *G*, thyroid cartilage: *H*, epiglottis; *K*, cricothyroid ligament; *L*, thyrohyoid membrane. (Ellis.)

died in a few months with symptoms of bronchopneumonia. Tracheotomy had not been performed.

Congenital diaphragm of the larynx is of far more practical importance. v. Bruns made 13 observations up to 1893. Several more have since been added to these. The glottis is more or less occluded by a transverse membrane between the vocal cords, beginning in front and ending behind with a half-moon-shaped margin. Toward the anterior border the thickness is considerably increased (15 mm.), so that a vertical incision appears wedge-shaped. It may extend backward only a few millimetres or two-thirds the length of the glottis. The amount of functional disturbance is directly proportionate to the size of the membrane, or, more correctly, to that of the remaining opening.

According to v. Bruns, this membrane is due to insufficient obliteration of the embryological closure of the upper part of the air-tube described by Roth. How far Hansemann's assertion that the condition is due to intra-uterine inflammatory processes is correct, is beyond the author's knowledge, but the uniformity of conditions found would seem to indicate some error in development as the primary cause. Zurhelle and Semtner have described a membrane above the glottis.

FIG. 45.



The larynx in deep inspiration. 1, lingual surface of epiglottis; 2, its laryngeal surface; 3, [illegible] 6, cushion of epiglottis; [illegible] posterior line of [illegible] cartilages surmounted by [illegible] cartilages of Wrisberg; [illegible] ventricular bands [illegible] process; [illegible] thyroid cartilage; [illegible] 23, spaces between tracheal [illegible]

Treatment.—Treatment in the majority of cases has been successful by [illegible] methods. Attempts to remove the diaphragm with a knife [illegible] have repeatedly been unsuccessful on account of the [illegible] of tissues. H[illegible] and S[illegible] were obliged to resort to laryngotomy and excision of the membrane. v. Bruns recommends a method of [illegible] with preliminary tracheotomy. This is applicable in [illegible] cases not sufficiently influenced by simple incision, and he considers that laryngotomy is only justifiable after attempts at dilatation have proved useless, especially since laryngotomy does not render subsequent dilatation unnecessary.

MALFORMATIONS OF THE TRACHEA.

These are hardly ever subjects of surgical interference. Congenital fistulæ will be omitted because a sinus of the neck ending in the trachea has not been demonstrated beyond question. Congenital fistulæ of the œsophagus and trachea are considered under the head of Malformations of the Œsophagus.

In a case of congenital scabbard-trachea described by Schmidt, due to primary malformation of cartilage without external pressure, tracheotomy was followed by a fatal result.

LARYNGOCELE AND TRACHEOCELE (AËROCELE).

Although the importance of increased expiratory pressure in the etiology, and especially in the growth of air-containing cysts connected with the interior of the respiratory tube is not to be undervalued, yet the fact that true aërocele is present at birth will justify considering this rare affection in connection with congenital malformations. Petit in 1889 collected the cases of aërocele reported and found 41 observations, many of which, however, especially the older ones, could not withstand scientific criticism.

Etiology.—Aërocele may be observed at any time of life. The condition is either congenital or acquired. The congenital variety, however, does not become manifest as a rule until later in life. The bulging of the wall increases with repeated or sudden marked increase of the internal pressure (coughing, crying), and a palpable and visible tumor develops.

Congenital air-cysts are shown anatomically to be hernia-like pouches of the mucous membrane, and are lined therefore with cylindrical or fimbriated epithelium. They usually involve the side of the tube, and are bilateral or unilateral. Ledderhose, who collected 8 cases in 1885, explains the anomaly, as does Bennett, Gruber, and Ehlers, as an error of animal evolution. The condition corresponds to the laryngeal sac normally present in the gorilla and orangoutang. Mamlok in 1899 increased the number of cases reported to 18. All of the patients were males. The distended laryngocele ventricularis (Virchow) consists either of an intralaryngeal air-tumor only, or protrudes through the thyrohyoid membrane. Median laryngocele has been reported by Hutchinson and Madelung, and was considered to be congenital. This view, however, has been attacked because the sac-wall was found to be tuberculous. It has been demonstrated by Rokitansky that tracheal hernia may be due to a sac-like distention of mucous glands, specimens of which have been demonstrated. Hernia-like bulging of the mucous membrane due to congenital defect of the cartilage has also been reported. The variety situated in the anterior wall was formerly supposed to be an incomplete internal fistula due to faulty union of the visceral folds. (Luschka.) Lateral diverticula in the lower section of the trachea were found by Chiari, and considered to be due to supernumerary bronchial rudiments. Madelung objects to the theory that air-cysts are produced by perforation of an ulcer of the wall, claiming that under these circumstances emphysema would result. In the author's opinion this objection is valid. The same objection applies still more as regards the traumatic lesions of the wall. On the other hand, it seems quite plausible that spurious aërocele may be due to substitution of air for the contents of a ruptured peritracheal abscess. Petit quotes an example of this sort.

Diagnosis.—The diagnosis is based upon the presence of a tumor increased in size on coughing or with any other increase of internal pressure, and diminishing in size with external pressure. The change of volume may be associated with a variety of murmurs. In the case reported by Ledderhose the seat of rupture in the thyrohyoid membrane could be felt, and by stopping this with the finger, the cyst was prevented from distending. The danger of making an error in diagnosis is greater with air-cysts of the trachea. The tympanitic tone over the tumor is justly considered a deceptive sign by Schrötter because of the proximity of the trachea and the apex of the lung. Absolute information can be obtained only by finding air on puncture or incision, or demonstrating a communication with the respiratory tube at the operation. Vascular goitre offers the widest opportunity for error in diagnosis, for it is well known that they may vary extremely and rapidly in size with variations in intrathoracic pressure.

Symptoms.—Many of the air-tumors described are incidental conditions that produce no symptoms, at least none that necessitate interference. Others annoy the patient on account of their rapid growth or produce dyspnœa by pressing on the larynx and trachea. Their removal is then indicated. In Benda's case sudden distention of the sac was followed by death from suffocation.

Treatment.—Of the various methods of treatment, operative interference seems to be the only rational step. Incision and excision of the cyst, closure of the communication with sutures or ligation of the peduncle of the cyst, may result in cure, as shown by the experience of Lücke, Baracz, and others. Drainage of the external wound is to be recommended so as to prevent emphysema. If the cyst contents are suppurating, the cavity should be packed as recommended by Madelung. In the case operated upon by Lücke, Ledderhose successfully excised the inner ventricular sac after preliminary laryngotomy. This was done four and a half years later on account of danger of suffocation. In cases of internal laryngocele Mamlok recommends removal of the upper wall by means of a double curette.

CHAPTER V.

INJURIES OF THE LARYNX AND TRACHEA.

CONCUSSION OF THE LARYNX.

LISTER first called attention to the fact that severe dyspnœa, unconsciousness, or even sudden death may follow trauma of the larynx without producing marked anatomical alteration.

Treatment.—The treatment of concussion of the larynx need not be considered. In the individual case, if aid is not given too late, the necessary steps are indicated by the life-endangering symptoms (artificial respiration, tracheotomy, analeptica). Whether these efforts will have been directed against the results of concussion of the larynx or not subsequent consideration alone will decide.

CONTUSIONS OF THE LARYNX.

Contusions of the larynx are produced by the same forces that will be considered in connection with fractures. The intensity is not sufficient to produce a fracture, or the consistence of the cartilage (great elasticity, absence of calcification) prevents such an accident. The subjective signs are similar to those of fracture. Objectively there is absence of typical fracture symptoms. Laryngoscopic examination may show ecchymosis or even hæmatoma with œdema of the mucous membrane and impaired motility of the vocal cords. Hopmann was able to collect only half a dozen observations. (Pacard's case was not mentioned, neither was a case of Robinson's quoted by Fischer.) Lubet-Barbon, on the other hand, claims that contusions are common, but he does not separate these sharply enough from fractures.

Prognosis.—The prognosis of uncomplicated cases is favorable. Recovery usually takes place rapidly, but alterations of the voice, amounting even to complete aphonia, may persist for weeks. Schrötter reports one case of perichondric abscess.

Treatment.—The treatment consists in rest and the use of local antiphlogistics. Liston's case probably belonged to this group of injuries and showed that at times tracheotomy may be necessary.

DISLOCATION OF THE LARYNGEAL CARTILAGES.

Uncomplicated traumatic dislocation of the arytenoid cartilage has not yet been reported. Hopmann observed one case in which there was simultaneous rupture of the vocal cord. The larynx had struck on the edge of a table. Diagnostically all of these cases belong to the laryngologist. Secondary disturbances of respiration may develop which necessitate surgical interference (thyroidotomy in Hopmann's case).

Dislocation or subluxation of the cricothyroid articulation (habitual dislocation) may be due to a relaxed condition of the capsule or to muscular action (deep inspiration, sudden nodding of the head, vomiting). The symptoms are pain at the moment of occurrence, anxiety, and even acute attacks of dyspnœa. According to Brown, it is easy to reduce the dislocation by pressure or by swallowing.

INJURIES TO THE LARYNX AND TRACHEA DUE TO MUSCULAR ACTION OR TO ABNORMALLY INCREASED EXPIRATORY PRESSURE.

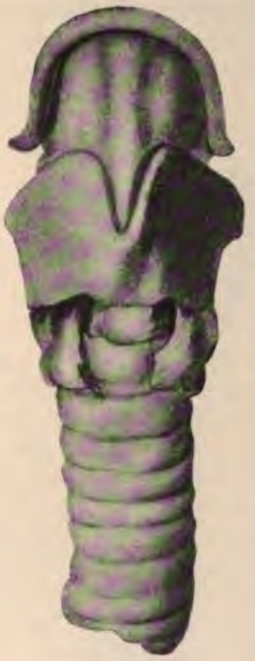
These injuries are rare. Rupture of vessels with ecchymosis or external hemorrhage, rupture of the vocal cords or of individual muscles such as follows severe straining of the voice or distressing attacks of coughing, are of laryngological interest specifically. However, coughing, or straining at childbirth, etc., have been followed by fracture of the larynx and trachea. In some cases pathological changes of the wall (tuberculosis) have been mentioned as predisposing elements.

FRACTURE OF THE LARYNX AND TRACHEA.

Fracture of the Larynx.—Until quite recently the views on fracture of the larynx were based on the work of Gurlt and Fischer.

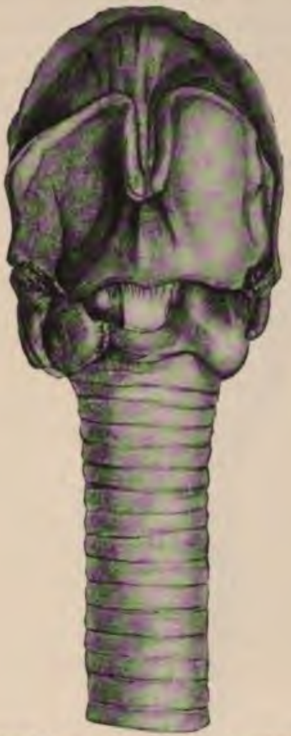
Hopmann collected in all 145 cases (75 by Fischer). Of 122 fractures, of which the cause is given, 84 were due to accident, 36 to suicidal attempts or violence, and 2 were produced by violent coughing and blowing. Of 82 cases collected since Gurlt's work, there are only 20 due to intentional maltreatment and 63 due to accident. The active forces produced either lateral compression of the larynx or anteroposterior flattening against the vertebral column. The applied force almost always affects the larynx directly. In rare cases, however, indirect fractures have been observed to be produced by the falling of heavy weights onto the head. (Hoffmann.) Incidental causes are falls against some object, kicks, etc. Violence refers to strangling with the hand or a cord. Fracture of the larynx is uncommon after hanging, according to Gurlt and Fischer. Remer found 1 case of fracture out of 201 cases examined, whereas Hoffmann and Lesser collected 16 cases of fracture of the larynx out of 50 cases of suicidal hanging. As far as the sexual distribution is concerned, males predominate in the statistics (31 men and 22 women in Fischer's statistics; whereas in Hoffmann's recent cases there were 64 men and 9 women). Of 54 of Hoffmann's cases, 1 case was between one and eleven years of age, 9 between eleven and twenty years, 10 between twenty-one and thirty years, 15 between thirty-one and forty years, 9 between forty-one and fifty years, 7 between fifty-one and sixty years, and 3 between sixty-one and seventy years. Fischer reports 37 cases of fracture between one and thirty years, 4 of these were in children between one and nine years; and Hunt reports 5 cases in children between one and four years. Although coincidence may play a considerable part in statistics so difficult to collect, yet the above facts seem to indicate that the elasticity of the larynx of a child does not render it exempt from fracture, and that it is not justifiable to conclude that fracture of the larynx is more common in old age because of the increased friability.

Fig. 46.



Median fracture of cricoid.

Fig. 47.

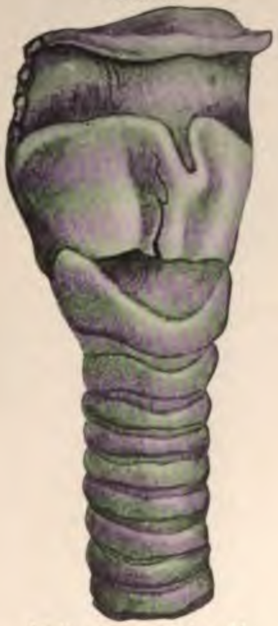


Lateral fracture of thyroid and cricoid.

Anatomy.—Single fractures of the thyroid are most common, then follow multiple fractures; all other varieties are rare. Of 124 cases of fracture, 63 were of the thyroid cartilage, 17 of the cricoid cartilage, 1 of the arytenoid cartilage, and 43 of several cartilages or fractures of the hyoid and larynx. (Hopmann.) Fracture of the thyroid cartilage is usually vertical, in or near the middle line, especially when it is produced by lateral pressure. The forces applied directly to the front produce more complicated types of fracture,—longitudinal, diagonal, transverse, comminuted.

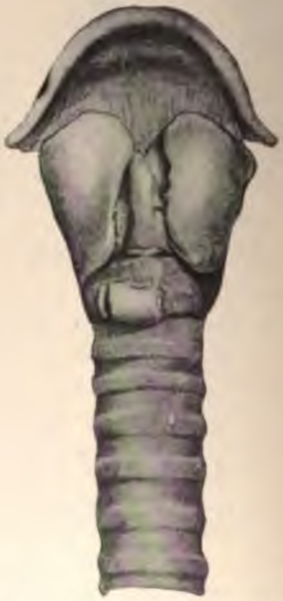
Separation of the upper cornu, which according to post-mortem examinations must be considered quite common, frequently escapes diagnosis during life. The cricoid cartilage breaks at the side, and more often on both sides at the same time. A single break in the median line is rare. Fracture of the body has been reported twice. The arytenoid cartilages are not infrequently involved in fractures where several cartilages are broken. It is as yet doubtful whether fracture of these alone ever occurs. Dislocation may be absent. The fragments, however, are apt to override or are pulled apart, or are dislocated inward into the lumen. The soft parts may or may not be lacerated. At times the perichondrium remains intact on one side, but is usually torn, as is also the mucous membrane (especially in comminuted fractures). The laceration may involve the muscles of the larynx, the vocal cords, the membranous portion of the wall and joints, and in individual cases may open the œsophagus. Hemorrhage of varying intensity may take place into the interior of the larynx or into the surrounding tissues. The bleeding as well as œdema is a constant feature of the clinical picture. The complications involve either the immediate neighborhood, such as happens with external wounds (horse kick), fracture of the hyoid bone, the lower jaw, or the trachea, and injuries to vessels and nerves; or they may affect more distant structures (fractures of the skull, chest, shoulder-girdle).

FIG. 48.



Median fissure of thyroid.

FIG. 49.



Median fracture of thyroid and cricoid.

Symptoms.—Although there are undoubted cases of fracture of the larynx that produce no characteristic symptoms, the rule is that immediately after the injury there develops a series of symptoms of varying severity and typical local signs that indicate the nature of the injury.

Unconsciousness is frequently the immediate result of the injury. Hopmann considers that this is reflex, at least in the cases of fracture produced by strangulation (commotio laryngis). Coughing is also a primary symptom, and the sputum is apt to be bloody. Coughing, swallowing, and talking are extremely painful. There may be complete aphonia or the voice is at least harsh. The interference with respiration may be considerable from the beginning, or later on becomes alarming. There will be stridor, the face becomes cyanotic, attacks of anxiety and suffocation occur, the pulse becomes small, and the skin cold and covered with perspiration. The increasing dyspnœa is caused by effusion of blood and œdema of the mucous membrane. In other cases it is due to primarily or secondarily dislocated fragments, or to emphysema of the tissues. The latter condition is of great symptomatic importance, for it indicates injury to the mucous membrane. It spreads rapidly to the neighboring regions and in individual cases may involve the entire overlying skin. This emphysema becomes dangerous when it involves the mediastinum, the pleura, or the interstitial tissue of the lungs. Its development is favored by the stenosis present, and especially by coughing, as emphasized by Hopmann, which increases the pressure physiologically in the respiratory tube with each attack.

Of fracture symptoms in a more restricted sense of the word, deformity is first to be noticed. This appears as a flattening or widening in the thyroid region: the prominent ends may be felt through the skin or gaps discovered between the fragments. Abnormal mobility may be recognized either by moving the fragments up and down or from side to side. Crepitation is rarely absent, but must be differentiated, as pointed out by Gurlt, from the grating produced by moving a normal larynx and pressing it against the vertebral column. In incomplete fractures extending backward and when the fragments are far apart crepitus is absent. Marked inflammatory œdema of the external soft parts, and especially marked emphysema, may render it impossible to obtain positive objective signs of fracture.

Diagnosis.—The laryngoscopic conditions have been reported in about a dozen cases. At first there are œdema and extravasation of blood, which when circumscribed may be sufficiently diagnostic, but when extensive may prevent viewing the interior of the larynx. In many cases examination with a mirror is rendered impossible by the severity of the initial symptoms. Experience would tend to show that examination with the mirror is of more value in observing the course and in recognizing some of the complications and subsequent conditions than for primary diagnosis (dislocation of the arytenoid cartilages, rupture of the vocal cords). The diagnosis in the majority of cases can easily be made from the history and the symptoms. Even fracture of the cricoid cartilage, which, according to Fischer, is, as a rule, discovered on the autopsy table, has been repeatedly diagnosticated ante mortem. Fractures of the cornu, however, are frequently not detected. At times severe complicating injuries of the chest or skull may cause fractures of the larynx to be overlooked, with disastrous results. When the severity of the local and general symptoms (swelling, emphysema, dyspnœa) renders an accurate diagnosis impossible at the time, the condition is such that detailed information is of secondary practical significance, because the symptoms themselves demand immediate treatment. It is far more important to make a correct diagnosis in cases in which there are at first no urgent symptoms, because experience shows that attacks of suffocation may arise suddenly (for instance, following displacement of a fragment).

Prognosis.—At the present time the prognosis of fractures of the larynx is far more favorable than it was twenty years ago. The statistics of Hopmann, as compared with those of Fischer, show a diminution in the mortality from 39 to 37 per cent., and when 4 cases of murder are excluded, to 33 per cent. The highest mortality, of course, is in comminuted fractures, 64 per cent.; whereas fracture of the cricoid cartilage, invariably fatal according to Fischer, now shows 71 per cent. of recoveries. It will be of interest to quote in this connection Hopmann's figures:

	Cases up to 1879.			Cases since 1879.		
	Number.	Recoveries.	Deaths.	Number.	Recoveries.	Deaths.
Thyroid alone	29	10	19	34	27	7
Cricoid alone	11	. .	11	7	5	2
Arytenoid alone	. .	. .	. .	1	1	
Several	21	1	20	22	8	14
Larynx	14	5	9	6	3	3
	75	16	59	70	44	26

This improvement in the prognosis is explained in part by the manner in which the older literature was collected (legal records which exaggerated the severity of the prognosis), but it is largely due to the early recognition and better treatment of the later cases.

The course of fatal cases may vary considerably. Death may take place immediately or after several hours, or suffocation may occur in the course of the next few days, and may be due to aspiration of blood, œdema, dislocated fragments, or mediastinal emphysema. At times fatal dyspnœa may develop more or less suddenly, the patient having been previously comparatively comfortable (secondary hemorrhage, sudden œdema, or dislocation of the cartilage). After these primary dangers have been overcome, the following conditions endanger the life of the patient in the subsequent course of the disease: perichondritis, purulent infiltration, and aspiration pneumonia.

Union takes place either with the formation of a callus or it may be fibrous. The later disturbances mainly consist in permanent constriction of the lumen of the larynx by scar-tissue or by dislocated fragments. These stenoses are often very persistent, so that the patient may be condemned to life-long wearing of a canula. On the other hand, slight fractures, especially of the thyroid, may heal without treatment. This sometimes happens even in more complicated fractures.

Treatment.—The first principle in treating fractures of the larynx is to maintain free passage of air to the lungs. When dyspnœa is present or when suffocation is imminent, tracheotomy is to be performed immediately without waiting for a fresh attack of dyspnœa, because when this is done death may precede the intended operation. When dyspnœa is absent, it is more difficult to decide what to do. The author accepts the indications emphasized by Hopmann, who recommends prophylactic tracheotomy when emphysema develops, when comminuted fracture exists, or when there is considerable mobility of the fragments. When all of these symptoms are absent, in a hospital, for instance, where the injured individual is under constant medical observation and the tracheotomy case is at hand, it is justifiable to wait. In practice, however, outside of the clinic, Hüter's dictum still applies: Tracheotomy is to be performed in every case of fracture of the larynx as soon as the diagnosis is made. The sooner tracheotomy is performed, the easier it is and the less the danger. Later it may be very difficult on account of infiltration of the soft parts, distention of the veins, and emphysema. When emphysema of the mediastinum or the pleura is well developed, tracheotomy is useless, whereas it may prevent these conditions if performed at the right time. The surgeon's duty does not cease after opening the trachea. Sometimes considerable hemorrhage occurs into the trachea. This will be considered more in detail in connection with injuries to the larynx.

Of the measures that treat the fracture directly, only those recommended by Wagner will be mentioned. These serve the purpose of rendering the fracture aseptic and keeping it so, of preventing secondary hemorrhage, and of guarding against subsequent stenosis. Wagner advises division of the larynx in the median line after packing the trachea and separating the two halves. The entire lumen may then be filled with iodoform gauze. After the primary danger has passed the thyroid cartilage may be secondarily sutured. When this is not possible or produces stenosis, the loose piece of cartilage should be excised. Mikulicz recommends the use of a glass canula instead of packing. Until surgical aid may be had it is advisable to keep the patient quiet and prevent coughing as much as possible, so as to avoid emphysema. For this purpose Hopmann recommends opium and cocaine or injections of morphine in the vicinity of the seat of injury.

Fracture of the Trachea.—The frequency of fracture of the trachea is about one-third of those of the larynx. Brigel collected 33 cases in 1895, and Hopmann was able to add 12 more to these (5 cases of injury to the bronchi in Hopmann's statistics are not included). The etiological factors are in the main those that have been considered in connection with fracture of the larynx. In a certain group of cases overstretching of the trachea is found to be the cause. Compression of the upper part of the chest may produce fractures low down, and force applied from within outward leads to rupture by suddenly increasing the intratracheal pressure. Violent coughing or explosion of powder in the mouth might be mentioned in this connection. A large percentage of children are affected (13 cases), which is not the case with fractures of the larynx. In more than a third of the cases (17) the fracture of the trachea was associated with fracture of the larynx, with or without involvement of the hyoid bone. Complicating injuries may involve the ribs or the sternum (19 cases), or there may be penetrating wounds, contusions, and lacerations of the œsophagus, and injuries to the cervical nerves. In the majority of the cases the separation is complete and transverse; the injury is rarely a fissure. One is most likely to meet this injury immediately below the larynx, or in the region of the bifurcation, one bronchus being torn off. Diagonal fractures have been found less frequently, and longitudinal ruptures are still more common. The latter may involve almost half the length of the trachea. When transverse separation has taken place, the ends may be several centimetres apart, the lower one being pushed to one side. With longitudinal tears, the cartilage is pressed into the lumen. A case of Lagg's is anatomically peculiar. There was an intussusception of the third into the second tracheal cartilage, following violent muscular action.

Symptoms.—The symptoms even in non-complicated cases vary little from those of fracture of the larynx. Pain is felt above or behind the manubrium sterni. Breathing is gurgling and tracheal râles can be heard. Dyspnœa and emphysema are the chief signs, the latter being first deep-seated and gradually extending to the surface. The classical signs of fracture, abnormal mobility and crepitus, have never been demonstrated because emphysema makes it impossible to palpate the seat of injury.

Diagnosis.—The diagnosis consists chiefly in determining that the larynx is intact, in the presence of symptoms that oblige one to assume injury to the respiratory tube. Aside from the history, the localization of the pain will at times give considerable aid in determining the seat of rupture.

Prognosis.—The prognosis of fracture of the trachea is unfavorable. In fractures of the trachea alone the mortality is 57 per cent. (12 recoveries, 16 deaths); in those complicated with fracture of the larynx, 70.6 per cent. (cured 5, died 12). Of those of the first variety that recovered, 11 had no tracheotomy. Of the laryngotracheal fractures, 4 recovered with tracheotomy and 1 without. In cases that progressed favorably the emphysema diminished after the third day. After recovery, which took place in the uncomplicated cases between ten days and six weeks after the injury, there remained sensitiveness to pressure, a tendency to cough, and some dyspnœa. A sinus, due to necrosis of cartilage and slight stenosis, was observed in a case mentioned by Küster. In the fatal cases the time at which death takes place varies as in fractures of the larynx. In these cases death is sometimes due to suffocation. Other causes of death are bronchopneumonia and perforation of the innominate artery by an abscess forming at the seat of fracture.

Treatment.—The same principles apply in the treatment of laryngotracheal fractures as in cases of fractures of the larynx. When the trachea alone is fractured, expectant treatment may be followed (rest, fixation of the head, ice) as long as dangerous symptoms are not present. This might apply to those cases that are several days old before they come for treatment or where an early diagnosis has not been possible on account of insufficient evidence. It seems dangerous in spite of all statistics to act otherwise than in case of fracture of the larynx after a positive diagnosis has been made. It is not possible to know whether and how rapidly emphysema is going to develop. If it is possible to expose the seat of fracture through an incision, this latter symptom may disappear without the introduction of a canula, provided the rupture is not extensive. Care should be taken to see that the air coming from the tracheal wound escapes externally. Complete transverse separation of the trachea will be considered in connection with wounds of the trachea.

WOUNDS OF THE LARYNX AND TRACHEA.

Gunshot-wounds.—Gunshot-wounds are practically only a special class of complicated fractures. The material which use has been made of is in large part from the great wars, for gunshot-wounds of the larynx and trachea are rare in times of peace. They are, however, very uncommon in time of war compared with the total number of injuries. Witte calculated from the statistics of the wars in the second half of the last century that injuries to the larynx and trachea constituted 0.04 to 0.05 per cent. of all injuries. In the American War of the Rebellion, of 235,585 gunshot-wounds 82 were of the larynx or of the trachea (0.035 per cent.). The statistics of the German army in the war of 1870–71 show only 61 wounds of the larynx and trachea—*i. e.,* 0.06 per cent.—out of 99,566 wounded that came to treatment. Of these, 55 were gunshot-wounds, 4 due to shell-splinters, 1 incised and 1 stab-wound. There will be found simply a hole in the thyroid cartilage, or more frequently comminuted fractures, laceration of the vocal cords and epiglottis. Gouged-out wounds are the result of a projectile tearing out pieces from the surface of the cartilage without opening up the lumen. Several cases of gunshot-wounds of the thyroid cartilage without injury to the skin are on record. Of course, the projectile may produce a variety of injuries in its course (vessels, nerves, œsophagus—the latter is frequently opened) before it leaves the body or is arrested. The ball has been found repeatedly in the larynx, and has been coughed up or removed immediately, or only after years. Sharp shell-splinters may separate the larynx from its surroundings just as if done with a knife. Gunshot-wounds heal by forming fibrous tissue that gradually becomes cartilaginous, or ossifies at times in older people.

Symptoms.—The symptoms of gunshot-wounds are chiefly those of a compound fracture, except for the characteristic external wound. Emphysema is infrequent, a fact that is largely explained by the free escape of the air, at least through short wounds.

Prognosis.—The prognosis is about the same as that of fractures produced in other ways. Among the causes of death may be mentioned wounds of neighboring organs, infection (purulent infiltration), and suffocation. It must, however, be remembered that the majority of observations were made at a time when the principles of treating gunshot-wounds differed materially from those that are considered correct to-day. Witte calculated the percentage of recoveries in 12 cases of gunshot-wound of the larynx to be 62.86 per cent.; in those of the trachea, 50 per cent. In the Franco-Prussian War, 53.5 per cent. of 43 uncomplicated wounds of the respiratory tract recovered, whereas all of the complicated injuries resulted fatally (18). Of 7 gunshot-wounds of the bronchi, only 1 recovered. Even in favorable cases there remain persistent disturbance of the voice, stenosis of the larynx (more rarely of the trachea), fistulæ, and even extensive defects resulting from necrosis of cartilage. In the cases of recovery in the war of 1870 the treatment varied from fifteen to one hundred and forty-five days, averaging forty-eight.

Incised and Stab-wounds.—The vast majority of the cases belonging to this group are produced by suicidal attempts or some attack on the life of an individual. Stab-wounds are produced chiefly in the latter way. Accidental incised or punctured wounds of the air-passages are rare. They may be secondary to a fall upon some sharp object, such as a pitch-fork or knife.

The incised wounds of suicides are almost always transverse, and, as Fischer points out, their direction is from above on the left side downward to the right (right-handed individuals). Of the cases collected by Durham, the thyrohyoid membrane was injured 45 times, the thyroid cartilage 35 times, the cricothyroid membrane or the cricoid 26 times, and the trachea 41 times. Aside from superficial incisions into the cartilage, complete transverse separation down to the œsophagus, and even through this to the vertebral column, has been reported, especially in the insane. The cartilages may be cut into several pieces by repeated attempts or by turning over of the knife (sometimes with a small external opening), and at times almost complete auto-excision of the larynx has been found. Completely separated pieces of cartilage may fall into the trachea or occlude this if hanging by a piece of mucous membrane. This is especially the case when the epiglottis is partly severed. When the trachea is completely severed, the ends may be two or three inches apart, the lower disappearing behind the manubrium sterni or displaced to one side. It is a well-known fact that the large vessels are oftentimes not injured. In spite of this, hemorrhage plays an important part in the majority of wounds of the larynx and trachea. The bleeding is usually profuse and comes from injured vessels of the thyroid gland, of the larynx or overlying muscles. When the skin-wound is large, the bleeding is external, but with small wounds it takes place into the tissues, and in both cases into the lumen of the respiratory tube. (It should be mentioned that even in fractures considerable hemorrhage does occur at times.) With deep incised wounds one or both recurrent nerves may be severed.

Symptoms.—When the transverse wound is extensive, the edges are considerably separated, so that one may look into the open lumen. Air passes in and out with respiration, which is gurgling. Sometimes on inspiration the lower margin of the wound closes like a valve. Dyspnœa results, which may increase to complete asphyxia. This may also be due to blood that has flowed into the tube if the injured individual is not able to cough it out. At first it is fluid, giving rise to tracheal râles, but later it coagulates. A like interference with breathing may be produced by a submucous hæmatoma, dislocated bits of cartilage, and later by œdema, abscesses, and secondary hemorrhage. Emphysema occurs only when the external wound is small (stab-wounds), and does not correspond to the size of the internal wound, or when the trachea is completely divided and the lower section is displaced. Finally, it may be the result of irrational treatment (suture of the external wound without tracheotomy). The voice is whispered even if the injury is low down, because the air necessary for phonation escapes through the wound. There is usually considerable difficulty in swallowing, which is more pronounced the higher up the injury. When the œsophagus is injured, food may escape through the wound. This may, however, take place when the œsophagus is not injured, because the larynx is not closed as it should be on swallowing (on account of the injury to the muscles of the epiglottis, or because of bilateral injury to the recurrent nerves).

Diagnosis.—The diagnosis of penetrating wounds is self-evident when the external wound is large. When the skin-wound is small, however, emphysema and bloody expectoration will aid one in recognizing the condition. If these signs are absent, one should be very careful about probing.

Prognosis.—The direction of the wound has considerable influence on the prognosis. Longitudinal wounds are far more favorable than transverse wounds. The size of the wound is of importance, because dangerous emphysema or compressing extravasations of blood are more apt to occur with small wounds than with large ones.

Horteloup reported 21 deaths out of 88 large wounds—*i. e.*, 23.8 per cent.; and 11 deaths out of 21 (small wounds)—52.3 per cent. If the patient does not die in the first few days of hemorrhage or suffocation, there remain the dangers due to œdema of the glottis, secondary hemorrhage, aspiration pneumonia, and gangrene of the lungs. Death is reported to have occurred months after the injury, due to granulation stenosis. Septic complications no longer play so important a part as formerly. In the majority of the cases that recover the wound heals by second intention in thirty to forty days. When the wound heals by first intention, the convalescence is shortened ten to twenty days. Scar-tissue stenosis of the larynx with almost complete obliteration is quite common, and may come under observation after recovery is apparently complete. Strictures of the trachea are more uncommon, although complete occlusion of the upper end has been reported. Air fistulæ sometimes remain as such or are associated with stenosis. Permanent paralysis due to injury of the recurrent nerve is to be mentioned as a rarity.

The prognosis depends largely upon the treatment, not only as regards healing of the wound, but also with reference to restoration of function. Platt obtained a perfect result in 7 of 9 cases after primary suture. In one case a fistula of the trachea remained, and another patient, a man in poor condition, died of croupous pneumonia on the eighth day (no bronchopneumonia).

Treatment.—In the treatment of wounds of the larynx and the trachea the chief object is to establish free respiration and to stop hemorrhage. These ends are achieved simultaneously, because the moment dyspnœa is relieved hemorrhage ceases; and on the other hand, when no more blood flows into the air-passages the chief cause of the respiratory disturbance is removed. The first thing necessary is to hold the edges of the wound apart and compress them at the same time, so as to meet for the time being these dangers.

If considerable blood has entered the trachea and the patient is not able to cough it out, it must be sucked out with an elastic catheter. It is best to ligate all bleeding vessels. When this is not possible for incidental reasons (insufficient time or lack of instrument), packing with iodoform gauze is to be substituted; the entrance of air is assured by tracheotomy or a tube passed in through the external wound. Prophylactic tracheotomy is to be recommended because it overcomes a series of dangers and gives the surgeon a free hand to treat the wound. It is undoubtedly to be preferred to introducing a tube into the wound itself. Fistulæ and stenoses from granulations also may be avoided, and it is a valuable aid in placing the injured respiratory tube at rest. The conditions in the individual case will decide whether a fresh incision will be necessary for tracheotomy or whether a new longitudinal incision downward from the primary wound will be advisable. A considerable percentage of recoveries take place without tracheotomy, and it is therefore justifiable in cases in which there are no disturbances of respiration, no hemorrhage, and free drainage to postpone this operation, provided, of course, that the patient can be under constant medical observation.

Only after the primary danger of asphyxia and hemorrhage has passed—*i. e.*, after the surgeon has become convinced that in any individual case there is no danger for the time being—the question will be raised: What is to be done to obtain as favorable a convalescence as possible? In cases in which the complications are numerous—for instance, when the cartilage is extensively destroyed or the overlying soft parts are badly torn, or when the wound comes under observation after having become infected, where, therefore, there is no likelihood of healing by first intention—the line of treatment is clearly indicated. The wound must be cleansed as completely as possible (knife and scissors if necessary). It must be kept clean by packing with iodoform gauze and the parts placed at rest. This is most effectively done by position. Fischer recommends to sit the patient up in bed with the head flexed sufficiently to bring the edges of the wound in apposition, and to maintain this position by a cap and bandages. Experience with excision of the larynx has shown that the danger of aspiration pneumonia is somewhat better guarded against by placing the head low as recommended by Bardenheuer. If the patient is unable to swallow, nourishment must be administered with a stomach-tube; or if the injury is extensive, he must be fed by rectum. It is more difficult to decide what to do in cases in which the possibility of healing by first intention is not excluded. Not only would convalescence be shortened, but the functional result is, as a rule, apt to be better in cases of primary union. Primary union usually guards against stenoses and fistulæ, which are otherwise so common. The experience of the last ten years has shown that the doubt expressed by most prominent surgeons regarding suture of the larynx and trachea is largely unfounded, and that it is permissible to close these wounds under the protection of asepsis.

Platt defends this view on the strength of the nine brilliant cases of his own above referred to. He recommends suture under chloroform in every case in which the general condition of the patient will allow. The wound of the air-passage should always be closed, and a tube inserted if necessary through a new wound; if introduced through the primary wound, it is apt to affect the suture. Tracheotomy should be performed as a prophylactic measure when the trachea has been divided or when the tracheal wound is very extensive. This dictum also applies when the wound is in the vicinity of the vocal cords. Muscles and skin should be sutured and both corners of the wound drained so as to guard against the dangers of emphysema and retention of secretion. He considers that feeding by stomach-tube or by rectum is necessary only in exceptional cases. The suture material used by Platt was silk. The mucous membrane should not be included—only cartilage and connective tissue. Eight or ten stitches are necessary to unite a completely severed trachea. Platt's results, as well as a number of cases reported by individual authors, demand that this example be followed where there is any chance that the wound may run an aseptic course. The author has obtained healing by first intention in two cases of complete separation at the level of Morgagni's pouch. In cases of complete transverse division the most rational procedure, as shown by Küster, v. Eiselberg, and others, would seem to use a circular suture with simultaneous tracheotomy. Closing the skin-wound without suturing the air-passage is to be condemned, although cases healed in this way have recovered.

In cases of gunshot-wound the same general line of treatment should be followed as in compound fractures. Witte claims that prophylactic tracheotomy is indicated when disturbances of the voice and of breathing begin to show, when secondary hemorrhage is liable to occur, and when the foreign body is lodged near the larynx and cannot be removed. In military surgery Fischer demands that prophylactic tracheotomy be performed immediately if the injury has penetrated as far as the mucous membrane, when the injury of the cartilage influences phonation, or when respiration is interfered with by a foreign body or blood, etc., in the air-passages or in their immediate vicinity. Taking the possibility of prolonged transportation into consideration, prophylactic tracheotomy is also indicated even when the danger-signs present are slight. In the report of the medical department of the German army it is recommended that immediate tracheotomy be done even in cases in which the direction of the wound renders some injury of the air-passage highly probable. The percentage of recoveries after tracheotomy in the Franco-Prussian War and in the American Civil War was 35.

If a foreign body becomes lodged within the respiratory tube, the same indications for removal exist as with foreign bodies in other parts of the body. It is not practicable to refer here to all the methods of extraction. The danger of infection along a bullet-track when the projectile has passed through the respiratory apparatus should be remembered. The projectile was very difficult to locate in former times, but this task has been made much easier by the Röntgen rays.

BURNS OF THE LARYNX AND AIR-PASSAGES.

Burns of the air-passages are due to inhalation of a flame or hot air, by steam or hot fluids. Such burns are most frequently observed in England on account of the universal custom of preparing tea on the table. The individuals affected are usually young children (averaging three years of age). They attempt to drink the boiling water out of the nozzle of the tea-kettle, when the violent pain causes them to cry out, thereby allowing the heated fluid to reach the larynx, while the œsophagus and stomach are uninjured. Caustic burns are produced by acids or alkalies taken by mistake or administered intentionally. Hopmann reports a case in which a tube of compressed ammonia exploded and produced burns of the face and buccal cavity as well as of the larynx.

In every burn there will be œdema, especially in the region of the epiglottis and the aryteno-epiglottidean folds, redness, blisters, and even excoriations. Chemical caustics produce charring, which is characteristic of such burns. In burning by steam the primary œdema never descends below the true vocal cords; later, inflammation of the trachea and bronchi develops, and diphtheritic membranes may form as the result of the exudate and superficial necrosis. The mouth and pharynx become involved as the logical result of the manner in which the burns arise.

Aside from the dyspnœa due to swelling of the entrance to the larynx, there will be difficulty in articulating and swallowing, and sometimes spasms of the muscles of the tongue and pharynx as well as salivation.

Diagnosis.—The diagnosis is usually not difficult if a history can be obtained. In children the condition may be confounded with diphtheria when no history is to be had, or when it is falsely given, as pointed out by Pitts. According to Pitts, when burns by steam are extensive, the prognosis is not so uncertain as claimed by other authors. Pitts enumerates 15 deaths out of 70 cases of his own, 9 of which occurred after tracheotomy, and 3 after intubation and tracheotomy. Of the 63 recoveries, 8 had tracheotomy, 3 intubation, while the remainder were treated by rest in bed, steam spray, or local application of ice.

Treatment.—The treatment has already been indicated. If there is difficulty in breathing, one should not delay tracheotomy until the patient becomes exhausted and the blood surcharged with carbon dioxide.

FOREIGN BODIES IN THE AIR-PASSAGES.

The enormous literature bearing upon this subject indicates the important part that foreign bodies play in the pathology of the air-passages. Behrens in 1887 was able to collect 608 observations, including the works of Gross, 176 cases, and Kühn, 374 cases. Heller in 1890 collected 646 cases. Weist in 1883 collected 1000 cases, and by combining his statistics with those of older writers obtained 1674 cases.

The vast majority of foreign bodies reach the air-passages per vias naturales. Only rarely is entrance obtained through external penetrating wounds (bullets, needles, and broken-off tracheotomy-tubes), or on account of perforation from the neighborhood (foreign bodies in the œsophagus, cheesy degenerated calcified glands, or sequestra of vertebræ). Foreign bodies entering from above usually come from the mouth, rarely from the nose, and are pushed down or slide down; some enter from the stomach by way of the pharynx (vomiting), and finally some come from the buccal cavity itself, such as teeth, sequestra, pus from tonsillar and retropharyngeal abscesses. The way foreign bodies pass the entrance to the larynx varies. At times they are carried in by the normal inspiratory current. This applies particularly to small substances of low specific gravity that are suspended in the air, for instance, flying insects and vegetable material. Much more frequently, however, objects are inhaled that have been placed in the mouth by the patient himself. The habit of young children of placing toys in the mouth explains why this accident is so common during childhood.

According to König, the relation of children to adults is as 2.05 to 1; and according to Heller, who collected 465 cases in which the age was given, 3 to 2.

Ordinarily a foreign body held in the mouth is sucked into the air-passage by sudden forced inspiration produced by fear, crying, laughing, stumbling, or falling. To this group belong the cases of aspiration of extracted teeth or of fragments of teeth or broken-off dental instruments, although the weight of these objects may also have some influence. It sometimes happens that the foreign body lodges in the pharynx first, and that the attempt to cough it up drives it into the larynx. Very frequently some disturbance in the coördination of swallowing ("going down the wrong way") allows portions of food to enter the larynx. While the morsel is passing, a sudden inspiratory effort (laughing, crying, speaking) opens the larynx. This occurrence is usually not serious in a normal individual, because the larynx closes immediately and frees itself from the particle of food by energetic reflex coughing. Large and hard substances, such as fruit-stones and nuts, become jammed, and angular, pointed substances may anchor themselves *in situ* (fish-bones and fragments of bones). On the other hand, if semisolid food is of sufficient volume to occlude completely or almost completely the lumen of the tube, then the spasmodic inspiration set up jams it into the larynx. König assumes that large pieces of food that stick in the œsophagus and reach into the glottis with the upper end are sucked into the larynx in this way. The mechanism just described applies chiefly to hurried swallowing of partially masticated food, and is especially noted in the insane, although normal individuals are not exempt.

It is well known that pathological disturbances of motion, such as diphtheritic paralysis, bulbar paralysis, inflammatory and neoplastic processes that destroy normal mobility of the parts, all favor the entrance of food particles and fluids into the larynx. The cessation of reflex irritability which allows the entrance of foreign bodies into the air-passages is the primary cause of another class of cases. These conditions are illustrated in a typical way in deep anæsthesia. Objects left in the mouth of the patient, for instance, false teeth, tobacco, etc., and teeth that have been broken off by the use of a gag, slide into the trachea. More frequently the substance that reaches the trachea is fluids, blood or pus during operations in the region of the jaw, in the mouth, and on the air-passage itself; these are not coughed up because of the absence of the normal reflex. The same applies to cases of injury to the head and neck associated with unconsciousness. Even when the reflexes are preserved fluids may collect in the air-passages and endanger life; for instance, when so great an amount enters that it cannot be removed quickly enough, or when exit is blocked. The former applies particularly to injuries of the air-passages (hemorrhages, see page 158); whereas both factors are active and are still further aided by the unconsciousness during an attack of vomiting while under an anæsthetic or while intoxicated. The dorsal position, unconsciousness, and lack of muscular control combined with spasmodic closure of the jaw, all favor collection of vomited material in the pharynx, thus shutting off the supply of air and producing a clinical picture that is probably familiar to every surgeon. For the sake of completeness, the possibility of active aid on the part of the intruding foreign body may be mentioned. This applies in cases in which living ascarides have been found in the trachea or in which leeches have wandered into the larynx, which were applied for therapeutic reasons in the mouth, or were swallowed with dirty drinking-water, an accident not uncommon in the South.

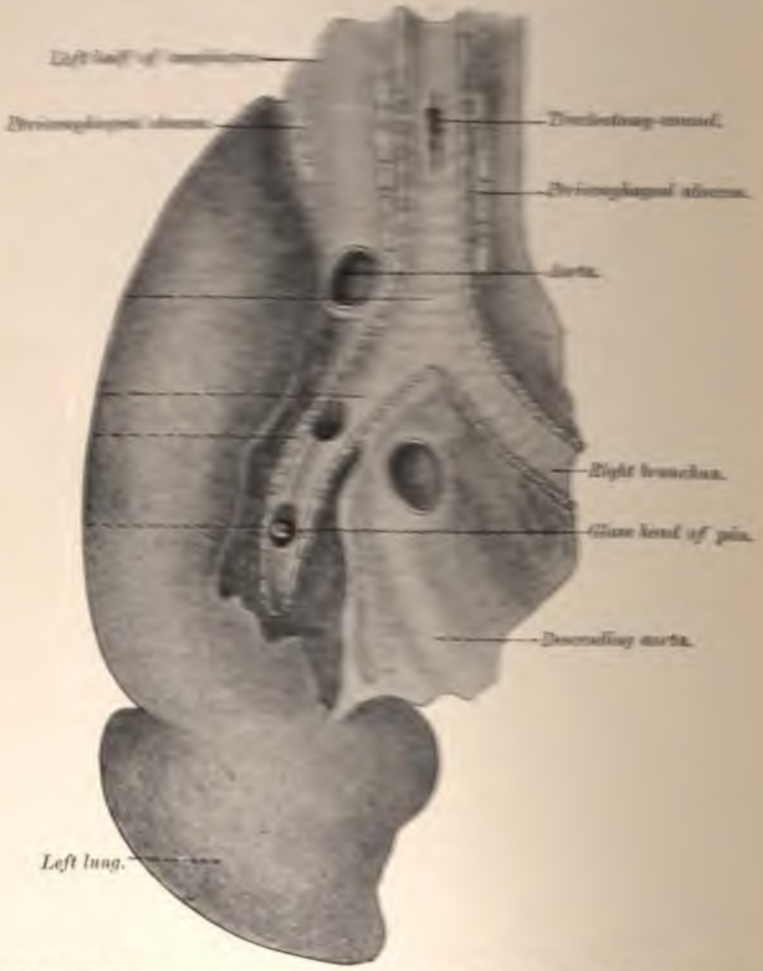
A table compiled by Behrens (234 cases) mentions not less than 80 different bodies that may enter the air-passages, and it would be quite easy to double this number if the statistics of the present day were gone over. From a practical standpoint, the classification, given by Adelmann seems more appropriate. He distinguishes: 1. Bodies with pointed, rough-cutting surfaces, for instance, bits of bone, nut-shells, fragments of canulas, needles, fish-bones, bits of glass, metal hooks, teeth, nails, spit-balls, crab-claws, chaff, etc. 2. Substances with smooth surface—(*a*) soft: mushrooms, bits of meat, leeches, worms; (*b*) hard: buttons, coins, stones, fruit-seeds, lead balls, glass beads, beans, peas. The author prefers to separate the latter two from this group because they possess the quality of swelling. Finally, there remain the soluble substances, such as bits of sugar, bon-bons, etc. It makes a difference whether hard substances are round or flat. 3. Fluid and semifluid material. Beans are the most frequent offenders. Next come bits of bone. In the 608 cases mentioned in the statistics of Kühn and Behrens there are 96 of the former and 77 of the latter; then come particles of food, 39; chaff, 27; coins, 21. The size of the foreign bodies varies considerably, and at times it is astonishing that substances so large can pass the glottis. Carpenter reports a case in which a plate with four teeth reached the bronchi and produced fatal empyema after thirteen years. The size of the foreign body, as well as its shape and the nature of its surface, are of importance in determining where it lodges. Generally speaking, round and smooth bodies are more apt to reach the bronchi than irregular-shaped substances. Of 646 observations collected by Heller, the foreign body was lodged in the larynx 132 times, in the trachea 113 times, in a bronchus 161 times, and location unknown 240 times. Statistics of the present day show that the foreign body is found on the right side 5 times to 3 times on the left. (Schäffer.) This predilection to enter the right bronchus is in all probability explained by its larger diameter and the very slight deviation of this tube from the direction of the trachea.

It is of practical importance to differentiate between substances that are movable, immovable, or jammed. The former condition is found only in the trachea and bronchi, whereas in the larynx the object is always immovable and is lodged either in the subglottic space, in the sinus Morgagni, or in the glottis itself. The seat of election is the point of bifurcation of the trachea. The intruding body is held fast in the trachea or bronchi only when it possesses sharp points or corners, or when it is at least in one diameter greater than the lumen of the tube.

Pathological Changes.—The tissue-changes that follow aspiration of foreign bodies depend on the consistence and situation of the body itself, and on the length of time it has been in place. If it has been in place but a short time, only a hyperæmia results. An angular, sharp substance may produce wounds of the mucous membrane or vocal cords.

Fig. 38.

Trachea seen from behind.


Left half of œsophagus.
Periœsophageal abscess.
Tracheotomy wound.
Periœsophageal abscess.
Aorta.
Right bronchus.
Glass head of pin.
Descending aorta.
Left lung.

Glass-headed pin (1.7 inches long) in bronchus for three months. Distance from opening in trachea to head of pin, 7.5 inches.

When an object remains jammed in the larynx for a considerable time, local inflammatory reaction takes place, or ulcers develop due to the continued pressure, even when there is no primary lesion. Mucoid diphtheritic membrane may also form in the vicinity, and inflammatory swelling (œdema of the glottis), hemorrhages, and increased secretion appear, and are favored by the violent expiratory efforts. The inflammation may attack the perichondrium, giving rise to abscesses and necrosis of the cartilage, followed by perforation into the neighboring tissues, externally, or into the œsophagus. The foreign body may be discharged from the larynx through the perforation, and in favorable cases it may be discharged externally. Sometimes it follows the well-known tracks of gravitation in the neck, and becomes still more of a menace to the patient. Not infrequently in cases of this sort fatal hemorrhages result due to erosion of large vessels (44 cases, Rivington). Every one of the large arteries and veins of the neck, even the heart, have been opened in this way. In other cases exuberant granulations spring up, or, when the foreign body is small, it becomes encapsulated in connective tissue. The inflammatory processes are of far more importance when the foreign body has become lodged in the air-passages below the larynx. It is not uncommon to have tracheitis, bronchitis with abundant purulent secretion, bronchiectases, secondary bronchopneumonia, abscess and gangrene of the lung follow this event. Empyema of the pleura may follow perforation, or purulent mediastinitis or pericarditis, and fatal hemorrhage due to erosion of the vessels has been reported as the outcome. Quite frequently pus and the corpus delicti have perforated the chest-wall and been discharged externally. This is more apt to take place when chaff is the irritating body.

When the lumen of a bronchus is completely occluded by a foreign body, atelectasis due to obstruction of the region involved is the immediate result; and finally, if pneumonia does not occur, the collapsed region becomes indurated. Vicarious emphysema of the free portion of the lung develops; and according to Gerhardt, the section of the lung situated beyond the foreign body may also become emphysematous, probably due to disturbances of nutrition. Interstitial emphysema results from bursting of the alveoli following violent attacks of coughing, and may extend to the subcutaneous connective tissue of the neck and chest. When phthisis is found at autopsy, accidental concurrence cannot be excluded, considering the great frequency of tuberculosis in this region. Nevertheless, there is ground for belief that the foreign body may have prepared the ground for the tubercle bacilli. The disastrous effects of foreign bodies in the air-passages occasionally observed must not cause the surgeon to forget that there are numerous cases in which foreign bodies remained for some time in the respiratory tubes without causing grave symptoms. In a case observed by Mackenzie a piece of bone was coughed from the bronchi after having been there fully sixty years. It may rarely occur that a foreign body in the lung becomes encapsulated, resulting in a permanent cure.

The symptoms depend also on the size and consistency of the foreign body.

In the larynx the intruding substance usually produces violent coughing, a sense of suffocation, cyanosis of the face, anxious excitement, and inability to utter a sound. The individual sensibility has considerable influence on the intensity of the initial reflex symptoms, demonstrated daily when undertaking insignificant endolaryngeal [illegible] If the attempts to remove the foreign body are unsuccess- [illegible] even if associated with gagging, or vomiting, then the patient [illegible] quiets down, although alarming attacks of suffocation may recur at longer or shorter intervals, perhaps due to change of position of the foreign body. In the interval there may be no symptoms whatever, or the signs of stenosis of the larynx may be present to a varying degree, produced either by the size of the foreign body directly or by secondary swelling of the mucous membrane. This latter condition results in hoarseness, eventually in complete aphonia, while in other cases the same symptom is caused by injury to the vocal cords or mechanical obstruction to closure of the glottis. Sharp and pointed [illegible] produce localized pain, which may be increased by external pressure, and especially by attempts to swallow. The sputum, at first bloody, finally becomes purulent, which indicates that the mucous membrane has been injured and that a secondary ulcer has developed.

The picture is entirely different when large soft bodies have been aspirated, for instance, on vomiting. These plastic masses immediately fill the lumen of the larynx completely. Oxygen-hunger is the predominating symptom. All accessory muscles are put in activity to force the entrance of air, producing but one result—that is, jamming the soft mass tighter and tighter in the larynx. The patient becomes asphyxiated and dies in a few moments without having coughed once. With solid bodies, on the other hand, a remarkably small space often allows of the admission of sufficient air to maintain life. If the foreign body has reached the trachea or bronchi, the clinical picture depends upon whether the body is movable or has become fixed. When the intruding substance drops to the bifurcation, an attack of coughing immediately throws it against the under surface of the vocal cord, thereby producing a reflex spasm of the glottis. As Trendelenburg expresses it, the foreign body bounces back and forth between these sensitive regions like a rubber ball between two walls, until the patient suffocates or until the object gets stuck in some place. In the latter case, if the size does not prevent the passage of air [illegible] all symptoms may cease until a sudden attack of suffocation [illegible] the gravity of the situation. Of the subjective symptoms, [illegible] dyspnoea, pain in the region of the trachea or in one side of [illegible] provided the foreign body has lodged in one of the bronchi, [illegible] symptom.

[illegible] physical signs are of great importance. At times the dis- [illegible] movable substance with respiration may be detected [illegible] the trachea. The patient himself may feel [illegible] of the substance against the interior [illegible] may be heard with the stethoscope over the trachea or on [illegible]. When the foreign body is large, this sound may [illegible] without a stethoscope. ([illegible], Dupuytren.) Buzzing [illegible] may sometimes be detected by auscultation over the trachea [illegible] A case has been reported in which a whistle lodged in the bronchus produced a sound during expiration. If the bronchus is entirely or almost completely occluded, the respiratory murmur in the portion of the lung affected is absent or very weak. The percussion-note is normal, at least at first. If the foreign body has reached one of the smaller bronchial tubes, these symptoms will be present over a certain part of the lung only. According to Riegel, the respiratory excursion of the chest-wall is diminished on the side affected; and according to Weil, the vocal fremitus is diminished.

Diagnosis.—First of all, the question must be settled whether there is a foreign body in the air-passage, and secondarily, where has the object lodged. The value of a reliable history, especially for the first part of this problem, does not need to be emphasized. It is, however, oftentimes unreliable because the patients—children and not infrequently adults—are not able to tell, and may even not suspect that a foreign body has reached the larynx, or the history is deceptive on account of the sensation that cannot be definitely localized and which is produced by some foreign body that has been swallowed.

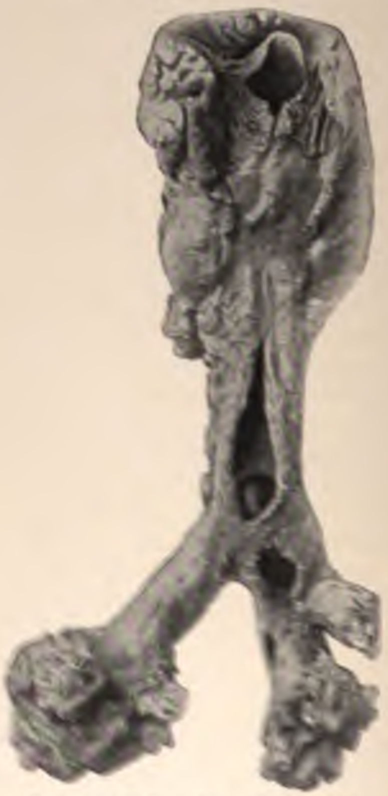
When the above-described symptoms are almost all present, a diagnosis will be possible even without a history, and not infrequently the seat of the object may also be determined. In cases in which suffocation is imminent, there is usually no time to spend on diagnosis. The thing to do then is to act. All indications are fulfilled and all immediate worry is removed when the corpus delicti flies out of the tracheotomy-wound with the first attack of coughing.

Where no dangerous symptoms seem to be present, one should not delay in making a laryngoscopic examination, which will usually detect the foreign body if it is still within the larynx. At any rate, it will enable one to eliminate by exclusion a series of diagnostic errors. In adults and older children this can usually be accomplished with cocaine anæsthesia, but in young children chloroform is required. Foreign bodies in the trachea and bronchi can sometimes be seen either by the usual laryngoscopic examination or by introducing a mirror into the tracheotomy-wound; and where laryngoscopy is not practicable, palpation of the interior of the larynx with a finger will sometimes enable a diagnosis. The Röntgen rays have been repeatedly used with success. Sprengel has recently shown that this method may also give rise to erroneous conclusions. He first hunted for a needle in the œsophagus and eventually found it in the left bronchus.

The similarity of the clinical picture to that of croupous stenosis of the larynx has repeatedly led to errors in diagnosis. Fever, as a differential diagnostic sign, is only of limited value, because the foreign-body statistics show that after twenty-four to forty-eight hours there may be considerable rise in temperature. The kind of attack and its duration may give some information, because with foreign bodies this is usually shorter and very violent in the first few moments, whereas in croup the symptoms of stenosis develop gradually as a rule.

Prognosis.—In the early stages the prognosis is largely dependent upon the degree to which the air-passage has become occluded. The nearer to complete obstruction, and the higher the seat of occlusion, the sooner will death take place. Round, smooth bodies, as shown by experience, lead to a fatal result much more quickly than flat bodies. The chances, of course, are most favorable when masticated food or semifluids have been aspirated, recovery in these cases being the exception. Secondary suffocation may be due to a sudden change in position of the object, such as turning of a coin or jamming into the glottis during an attempt to cough out the foreign body or by an increase in the volume of the offending substance. Beans lodged in one of the main bronchi are typical examples of the latter event, and the accident is well illustrated by two preparations in v. Bruns' clinic. The bean in both cases occluded the right bronchus and reached somewhat above the bifurcation. It subsequently swelled and finally occluded the lumen of the left bronchus. (Fig. 51.)

FIG. 51.



Bean in right bronchus. (Fürbinger.)

When there is no immediate danger of suffocation on account of the nature and location of the foreign body, then the length of time that the object has remained in the air-passage becomes a factor in the prognosis. The longer a body has been in place, the greater will be the anatomical changes to which the patient may eventually succumb, even after the corpus delicti has been expelled. Early removal is usually followed by rapid convalescence. If the intruder cannot be removed, death results sooner or later except in the cases in which encapsulation takes place.

Heller's statistics show the effect of the seat of the object on the prognosis. He calculates that the death-rate is 50 per cent. when the foreign body is in the larynx, 40 per cent. when in the trachea, and 61.6 per cent. when in the bronchi. If the cases of sudden death due to entrance of large objects into the larynx are not counted, and only those cases which reach the physician alive are considered, it will be seen, generally speaking, that the prognosis is graver the deeper the seat of the foreign body.

It is, of course, self-evident that the prognosis may be greatly improved by prompt and rational treatment. This is especially the case with foreign bodies lodged in the larynx. The percentage of recoveries in this class of cases has been materially bettered since the introduction of laryngoscopy and the general practice of tracheotomy. Kühn placed the mortality up to 1861 at 68 per cent., whereas Behrens in 1887 found it to be 35 per cent.

The total mortality following aspiration of foreign bodies regardless of treatment, taking all statistics together, averages 33 per cent. (Opitz, 33.5 per cent.; Gross, 25 per cent.; Kühn, 42.2 per cent.; Durham, 33.4 per cent.). The foreign substance is expelled spontaneously in about 26 per cent. of the cases (Opitz, 21.2 per cent.; Gross, 27.8 per cent.; Aronsohn, 32.4 per cent.; Kühn, 22.2 per cent.; Durham, 29 per cent.; Behrens, 24 per cent.). It must, however, be remembered that a large number of the cases in which expulsion follows the first attack of coughing do not come to the physician's attention, and therefore escape enumeration.

Treatment.—It makes no difference what one's views are regarding tracheotomy in general; the fact remains that no physician will deny the necessity of this step when the danger of suffocation is great. When the object is in all probability high up in the larynx (vomiting during narcosis), it is justifiable to remove the offending material with a finger. No time is wasted in this way during which we might be able to save an asphyxiated individual, for the seconds are precious during which the preparations for tracheotomy are being made. If the patient's head is allowed to hang down, the effort will be materially aided, as the author can testify from his experience. If large quantities of fluid have reached the trachea, the liquid should be aspirated by means of an elastic catheter immediately after tracheotomy. The expectant treatment to which so many patients formerly fell victim is to be condemned. This method is only justifiable in a small number of cases in which a small foreign body has fallen far down into a bronchus where it cannot be reached. Chaff is apt to do this, and can never be extracted if the points project upward. It is justifiable to try expectorants or emetics (apomorphine, Riegel). Generally speaking, emetics are unreliable, as emphasized by Gross, and their use is not without danger (5 successful cases to 46 failures). Inversion and violent shaking of the body does not enjoy its former popularity. Even Weist, who is probably the most conservative of modern authors, considers that manipulations of this sort are dangerous and only justifiable after previous opening of the trachea. If this method is to be used, the simplest way is to follow Sanders' suggestion, and allow the body to hang over the edge of the bed and rest on the hands during the attacks of coughing.

Operative interference is the special form of treatment that is most rational. The kind of operation will depend first of all on the seat of the foreign body. Whenever conditions make it possible, a laryngoscopic examination should be made, and if the foreign body is in the larynx and seems to be within reach, an attempt should be made to remove it with the aid of a mirror, cocaine, or chloroform in children). The danger of sudden attacks of suffocation produced by unintentional displacement of the foreign body during endolaryngeal manipulations justifies Trendelenburg's advice, always to be prepared for tracheotomy. Laryngologists point with pride to their success in recovering foreign bodies, and claim that in many cases tracheotomy is unnecessarily performed. Only foreign bodies lodged in the upper trachea and larynx can be removed per vias naturales, although exceptionally it has been possible to remove a foreign body from the deeper seated portion. Recently several cases have been reported in which Killian's bronchoscopia superior made it possible to extract foreign bodies from the bronchi. Where endolaryngeal extraction is counterindicated (dangerous stenosis, ignorant patient, especially children, and foreign bodies low down) or when the attempt has been unsuccessful, then opening of the trachea is justifiable. Tracheotomy is positively indicated when the foreign body is movable in the trachea, and most authors recommend operation when the intruding substance has become fixed in the trachea or bronchi. Numerous observations prove that a sudden attack of suffocation produced by displacement or swelling of the foreign body after relatively comfortable intervals may result fatally, an accident that oftentimes may be guarded against at least by timely tracheotomy. In some cases it may be possible to extract the substance through the wound under guidance of a small tracheal mirror after Voltolini, or a speculum after Pieniázek or Killian. An attempt should be made to grasp the foreign body with a long pair of forceps suitably bent, or to lift the offending article out with a spoon or with wire hooks bent especially for this purpose. Even if this is not successful, the foreign matter may become dislocated from its fixed position and expectorated. The wall of the trachea has been tickled with a feather for this purpose, and not infrequently with success. Huter recommends aspiration with a catheter when the object is small, and in a case of this sort inversion of the patient may be tried. Trendelenburg justly warns against too energetic measures in cases in which there is no imminent danger, pointing to the danger of injuring the mucous membrane with instruments. Oftentimes the object will be expelled through the tracheal wound after hours or days, so that it is best to make the incision as large as possible, and use no canula, so as to offer as little resistance as possible. The edges of the wound are held apart by dilators, such as were used with the old-fashioned instruments, or by hooks fastened around the neck with a tape. Bardenheuer tried to reach by pneumotomy a set of false teeth that were stuck in a bronchus and that had been accurately located by the Röntgen rays. The teeth were dislodged with a sound and expelled immediately. The author has become convinced that the danger of tracheotomy nowadays is insignificant compared with that of a foreign body in the air-passages, and does not hesitate, even when the object is situated in the larynx, to remove the offending material through an incision should extraction per vias naturales be impossible. It may be pushed up into the pharynx with a stiff elastic catheter or some similar instrument, and after tracheotomy the laryngoscopic examination may be repeated with much more comfort than was possible before. If all of the above-mentioned methods are unsuccessful, or if some sharp-cornered body is so fixed that its removal would mean extensive laceration, it is justifiable to split the larynx itself. The results of laryngotomy for foreign bodies are very good, according to Schüller. If possible, one should confine one's self to a partial operation. If a foreign body above the vocal cords (sinus Morgagni) or in the glottis itself cannot be removed without operation, the next step is to perform subhyoid pharyngotomy. Ten pharyngotomies were collected by Honsell, in three of which the foreign body had become lodged at the aditus laryngis. Lefferts reports a fourth case.

Provided the surgeon has decided to perform tracheotomy, the next question to decide is, where to make the incision. The generally accepted dictum is to cut as near as possible to the foreign body. Tracheotomy low down offers more favorable conditions for the removal of foreign bodies from the bronchi; whereas with substances in the larynx, tracheotomy high up with separation of the cricoid or even thyrocricotomy is more advisable. It is well to try to open the air-passage below the seat of trouble if possible, not only because there is less probability that stenosis may develop, but also because the danger of having the corpus delicti drop down and get away in the attempts at removal, is removed. If it is possible to examine accurately with a mirror before operation, the seat of the operation may be determined beforehand almost to a ring on the trachea, as in a case in v. Bruns' clinic, in which a piece of bone had stuck at the level of the third tracheal ring.

According to Kühn, of 141 cases operated upon, up to 1861, in which the result was known, 40 died, 28.4 per cent. Of 272 non-operated cases, 89 died, 51.7 per cent. Durham in 1870 calculated the death-rate to be 24.8 per cent. of 283 operative cases, and 42.5

per cent. mortality in 271 cases treated expectantly. Behren's statistics, covering the years from 1861 to 1887, include 99 cases in which the trachea was opened, with 24 deaths—*i. e.*, 24.2 per cent.; endolaryngeal extractions, 21, and no deaths; treated expectantly, 109, deaths 53, death-rate 48.6 per cent. Weist alone comes to other conclusions: operated, 330—died, 27.4 per cent.; non-operated, 599—died, 23.2 per cent. The death-rate of statistics should not decide the question of operation. The clinical picture of the particular case and the unfortunate cases should guide the surgeon. Those that died after operation did not do so because they were operated upon, but because they were usually operated upon too late. In an individual case the surgeon can never count on spontaneous expulsion of the foreign body. On the contrary, every hour that the offending material remains *in situ* lessens the chances more and more, while an operation furnishes conditions most favorable for its removal. In spite of Weist's figures, opening of the air-passages is the most rational procedure, except for the cases in which endolaryngeal methods can be used.

CHAPTER VI.

DISEASES OF THE LARYNX AND TRACHEA.

INFLAMMATORY DISEASES OF THE LARYNX AND TRACHEA.

In the majority of these cases the surgeon does not attempt to treat the disease itself, but tries to meet the indications and remove any hindrance to the supply of air. Whatever the cause in an individual case, opening of the air-passages at some place or other will be considered. With some inflammatory processes surgical aid is only exceptionally necessary; with others this is the rule—*e. g.*, in croupous diphtheritic inflammation of the air-passages.

Croupous Diphtheria.—Diphtheria in general is a disease of childhood, and diphtheritic stenosis of the larynx is almost exclusively seen in children. The frequency of diphtheria increases from the first month of life, reaching the maximum between the third and fourth year (10 per cent., Krönlein; 17 per cent., Hirsch; and about 30 per cent., Rose), and then diminishes to the fifteenth year. Tracheotomy is most frequently performed during the first year of life (78 per cent., Hirsch), and decreases in frequency year by year. This fact is based on the anatomical relations of the infant's larynx, which is considerably more influenced by a membrane or by swelling of the mucous membrane than the relatively wider air-passage of older individuals.

Sex was formerly supposed to have some influence on the frequency of the disease, but recent statistics have shown this theory to be unfounded. Various statistics show that the season of the year is of considerable influence, for in the autumn months, generally speaking, cases of diphtheria are more numerous and more severe. The term secondary croup has been applied to inflammations with fibrous exudate in the course of acute infectious diseases or during the convalescence. The acute exanthemata, whooping-cough, and typhoid are most frequently associated with this condition, but it has long been supposed that a certain number of these cases are true diphtheria. Bacteriological investigation in the future will decide whether this is true. Sanné mentions that the respiratory organs are almost exclusively affected in diphtheria following measles.

Pathological Anatomy.—Croupous diphtheritic inflammation is associated with a pseudomembrane that is at times only loosely connected to the underlying tissue, so that it may be removed without any loss of tissue (croup). At times it is intimately adherent to the deep-seated layers of tissue and can be removed only with considerable force and loss of tissue (diphtheritis). Membranes appear as gray or yellowish-white coatings, varying in thickness (2 to 3 mm.), either covering continuously a larger portion of the wall or less frequently as scattered islands. The mucous membrane of the larynx and trachea is especially prone to the formation of croupous membranes, contrary to that of the pharynx. This applies particularly to that portion of the larynx lined with cylindrical epithelium, and still more to the trachea and bronchi, while those regions lined with squamous epithelium are more frequently subject to deeper-seated diphtheritic changes.

"Croup" and "diphtheritis" in the anatomical sense are to be sharply distinguished from the etiological term "diphtheria."

The mucous membrane is intensely hyperemic beneath the croupous membrane, and around the periphery of the focus—*i. e.*, where the process first develops. There are catarrhal swelling, which especially in the larynx may extend to the submucosa, and mucopurulent secretion, the latter playing an important part even when older membranes have been removed. When diphtheritic membranes separate, a granulating ulcer remains that finally heals and leaves a scar. It is not common to have the diphtheritic necrosis extend to the perichondrium and give rise to subsequent perichondritis. The membrane cannot be proved to be the cause of death in the late fatal cases.

Histologically the membrane consists of fibrin, disintegrated layers of tissue (coagulation-necrosis of epithelium and connective tissue), leucocytes, red blood-corpuscles and their derivatives. The method of formation is the same in the croupous and diphtheritic varieties; the differences depend chiefly on the depth, for the croupous membrane involves only the epithelium and is limited by a basal membrane which is intact or but slightly changed. In the first variety the necrosis involves the basal membrane and sometimes the underlying connective tissue. If the epithelial covering is absent after the first membrane has separated, the new deposit must, of course, consist of fibrinous exudate, the secondary croupous membrane; or when the necrosis repeats itself, the membrane may resemble the diphtheritic variety. This well-defined basal membrane in all probability explains the predisposition to the formation of croupous membranes on mucous surfaces lined with cylindrical epithelium. The epithelial necrosis involves the opening of the glands which are dilated, and in severe cases may attack the glands themselves, thereby rendering the chances for subsequent regeneration of epithelium worse. The seat and extent of the inflammatory process vary considerably and depend largely on the character of the epidemic. Usually the larynx becomes involved by extension of some similar process in the pharynx. The exudate may even extend downward to the finer bronchi (descending croup). It is uncommon to have the process begin in the deep-seated air-passages and progress upward (ascending croup). In some epidemics the larynx alone or the larynx and trachea are affected, but it must be taken into consideration that the lesion in the pharynx may be overlooked or may have subsided at the time of examination. It is rare to have tracheobronchitis without involvement of the larynx.

Krönlein found in 241 cases, 46 with lesions of the larynx without disease of the nose or pharynx; 164 times stenosis of the larynx was combined with disease of the upper air-passages, and 31 times the latter alone were affected. Sahli found membranes in the pharynx 94 times in 363 cases; in the larynx 52 times; and in the larynx and pharynx together, 112 times. Rose made the following observations on 4465 cases covering a period of twelve years:

	Cases.	Per cent.
Diphtheria of fauces and nose	1319	29.5
Diphtheria of fauces and nose with laryngeal croup	1222	27.4
Diphtheria of fauces and nose with laryngobronchial croup	1380	31
Croupous laryngitis	283	6.3
Laryngo-tracheobronchitis, croupous	261	5.8

Of 437 cases of diphtheria examined bacteriologically by Blattner, there were 236 without involvement of the larynx, 43 of the larynx without the pharynx, and 158 of pharynx and larynx. Rauchfuss found that the frequency of laryngo-tracheobronchitis (croup) was 48 per cent. of 382 cases collected from the autopsy reports of various authors. The statistics collected from autopsy reports do not give a correct idea of the actual frequency of the disease because of the high mortality of tracheal bronchial croup. This is especially evident in Blattner's statistics, who found the bronchi involved but 8 times and the trachea 42 times in 437 observations. Finally, there remain to be considered changes in the lung due to laryngotracheal diphtheria. These secondary conditions have certain influence on the surgical treatment, and should be familiar to the surgeon. Some of these conditions are purely mechanical, direct results of stenosis; for instance, distention and anæmia of the upper portion of the lung, interlobular and subpleural emphysema, or hyperæmia and foci of atelectasis in the lower and posterior part of the lung. Inflammatory changes are in part due to the direct influence of the diphtheria bacilli and partly to secondary infection with other organisms, which is favored by the mechanical results of stenosis. The most common complication in the lung is bronchopneumonia; croupous pneumonia is less frequent. Some observers have found pneumonic infiltration in about five-sixths of all autopsies while others claim it to be much less common. The type of the epidemic evidently has considerable influence. The mechanism of stenosis will have to be considered more in detail, because it is surgically the most important feature of the clinical picture. The membranes alone may, of course, dangerously diminish the lumen of the larynx. This applies to a much greater degree to the secretion forming a crust on the surface of the membrane. Inflammatory swelling of the mucous membrane in certain regions of the larynx, as the subglottic space, plays a part not to be underrated. When the infiltration extends to the muscles, stenosis is favored by immobilization of the arytenoid cartilages a fact to which Pieniázek has called particular attention. These conditions, of course, produce dyspnœa, even in cases in which membrane is absent from the larynx. The trachea may be extensively involved without manifest signs of obstruction, whereas involvement of the smaller bronchi gives rise to immediate and acutely dangerous respiratory obstruction. This condition can frequently be observed in children after tracheotomy.

Symptoms.—The symptoms that may arise in the course of laryngotracheal diphtheria are partly due to simultaneous infection of the nasopharynx, partly to the general influence of the disease on the organism, and sometimes to complicating lesions in other organs. Here will be mentioned only those symptoms of the complicated picture that appear as the result of local changes in the trachea and larynx. Therefore the description of symptoms will be confined to those indicating the development of stenosis and to those resulting from obstruction. It has frequently been attempted to divide into stages the symptom-complex. This is perfectly justified if it is borne in mind that no sharp lines can be drawn between the individual stages, and that the development of symptoms is a gradually progressing process. Rauchfuss differentiates three stages: 1. Prodromal symptoms including those of acute laryngotracheal catarrh up to the appearance of stenosis. 2. Permanent and progressive symptoms of laryngostenosis with sufficient compensation. 3. Increasing stenosis with disturbance of compensation and asphyxia.

The first stage includes those symptoms produced by the local process in the pharynx or nose, as well as the general signs of infectious disease (fever, etc.). These may, of course, persist even in the later stages. Hoarseness is an almost constant symptom of this period, so is coughing, the barking character of which is almost pathognomonic of croup. Periodic transitory attacks of obstruction are sometimes observed in this period. In the second stage, gradually developing from the first, the cough slowly becomes noiseless and finally complete aphonia is present. From this time on the surgeon begins to take a practical interest in the case, chiefly on account of the signs of obstruction, the progress of which he should watch most carefully. Inspiration is associated with a noise (stridor) of bubbling, sawing, or crowing character, slight at first, but gradually increasing in intensity. After a short pause expiration follows, associated with weaker blowing sounds. Inspection now shows that both respiratory stages are accompanied by extreme activity of the accessory respiratory muscles, the alæ of the nose dilate with each inspiration, the muscles of the neck become tense, and on expiration there is abdominal straining. With increasing stenosis the amount of air passing through the occluded glottis is no longer sufficient in a given time-unit more than to equal the difference in pressure produced by the violent exertion of the dilator muscles of the chest. The softer portion of the thoracic wall now sinks in. The larynx descends markedly. The jugulum, supraclavicular fossa, and in emaciated children the intercostal spaces, the epigastrium, the lower portion of the sternum, and the lateral walls of the chest sometimes up to the third and fourth ribs, are retracted *in toto* by the contractions of the diaphragm, the central tendon of which has become a fixed point because the insufficient volume of air no longer permits of its descent. Inspiration is considerably prolonged during this period. The number of respiratory efforts increase at first, and may diminish later to 12 to the minute. Finally the prolonged inspiration is no longer capable of equalizing the negative pressure, so that when the muscular action of the chest ceases the thorax springs back into the position of expiration. It has been demonstrated laryngoscopically that the violent effort during inspiration increases the stenosis by allowing the vocal cords to be brought nearer together on account of the obstruction to abduction. When stenosis can be demonstrated objectively, there need not be any subjective sense of dyspnœa, but later this symptom becomes more and more annoying to the patient and finally increases, giving rise to fearful apprehension of suffocation. The children become restless, toss about, stand up, clutch the neck and try to cry out. The dyspnœa is, of course, increased by their efforts, and dangerous attacks of suffocation with severe cyanosis are the result. Sometimes a violent attack of coughing or the jamming of some loose piece of membrane or mass of mucus causes the attack, which ends in extreme exhaustion. The pulse-rate increases during the second stage (120 to 130), but diminishes in volume toward the last and becomes irregular (inspiratory omission, pulsus paradoxus, Gerhardt). In the third stage signs of insufficient oxidation of the blood that were only transitory during the second stage predominate. To these are added disturbances of circulation. Cyanosis is constant. The marked fear of suffocation gives way to a deceptive quiet due to carbon dioxide intoxication and exhaustion. Somnolence finally supervenes, at times interrupted by attacks of suffocation that become more and more infrequent. The formerly red face is now pale and covered with cold perspiration, the right side of the heart is dilated, the veins of the neck distended, and the pulse and breathing finally cease with the increasing asphyxia. The respiration, at the beginning of asphyxia hurried and superficial, is finally a tracheal rattle.

The above clinical picture is subject to considerable modification, due partly to the effects of diphtheritic poisoning, partly to complicating disease of the lung and to the varying rapidity with which the stenosis develops. Thus, when stenosis is fatal in a short time, or when death occurs during an attack of suffocation before the asphyxia stage has become developed, the end is accompanied by violent convulsions. Involvement of the bronchi in croup can only be recognized by the absence of stenosis, or after the latter has been relieved by tracheotomy. The temperature and rate of respiration increase considerably, and signs of asphyxia develop that are not influenced by tracheotomy and do not correspond to those produced by laryngeal stenosis. The breathing is bronchial and the expectoration, as long as present, is watery or foamy, and may contain membranous bronchial casts. The trachea, lined with pseudomembrane, is no longer sensitive to touch. When there is considerable stenosis of the larynx, the symptoms of bronchitis are usually overlooked and the signs found on auscultation are masked by the stridor.

It is of great practical importance to be familiar with a type of respiratory disturbance emphasized by Trendelenburg and observed in severe cases of nasopharyngeal diphtheria without lesion of the larynx. The children close the mouth while asleep, or, weakened by the general infection, are in a state of somnolence. The sound produced is due to the tongue falling against the swollen entrance to the pharynx. By introducing a piece of stomach-tube it may be possible to admit sufficient air, although the fatal result of the severe septic process may not be avoided. The disease always runs an acute course, although the rapidity of development and the duration of the individual stages may vary considerably.

Rauchfuss calculates that the first stage varies from one to ten days (average four), the second three hours to seven days (average three), and the third stage usually ends fatally in less than twelve hours, rarely lasting one to two days. Sanné has reported much lower averages (two and a half days, one and four-fifths days, and a few hours), but his statistics include many fulminating cases (death in one to two days in 10 per cent. of his cases). The statements relative to the duration of the disease vary also. On an average eight days pass until the signs of stenosis diminish markedly, or till death occurs, according to Rauchfuss (in severe diphtheritic cases six to seven days). Sanné's average was not quite four days. Complications may delay convalescence considerably, and not infrequently they result fatally. Convalescence is, of course, more protracted where tracheotomy has been performed than where no operation was necessary. This point will be referred to again.

The symptoms may improve during any stage, even marked stenosis may subside spontaneously, sometimes after expectoration of the membrane, although this taking all in all is a very uncommon piece of luck. Improvement manifests itself by diminution of the signs of stenosis, lessening of the fever and of the pulse-rate. The appearance of mucopurulent secretion is frequently considered a sign of improvement in the local process. Hoarseness or aphonia remains longer. Death is as a rule due to asphyxia secondary to stenosis or to some lung complication, or to severe toxæmia or sepsis. Pulmonary complications influence the mortality much more since stenosis of the larynx has become of less importance as a fatal element, the technic of tracheotomy having become common property. The largest number of fatal cases in which the immediate cause is suffocation are due to bronchial croup. Surgeons are powerless in this direction. Bronchopneumonia may develop in any stage of the disease, most frequently in the second—that is, about the beginning of the first week. Only those late manifestations that affect the larynx and trachea will be mentioned. Ulceration of the larynx with subsequent scar stenosis and complete [illegible] infiltration of the submucosa, and perichondritis are rare. Post-diphtheritic anæsthesia of the larynx or paralysis of the pharynx may result in deglutition pneumonia, usually at the end of the second week, and paralysis of the abductors may lead to secondary stenosis.

Diagnosis.—The diagnosis is usually made without difficulty. Gradual development of the clinical picture, prodromal signs, the presence of a diphtheritic process in the pharynx or nose, and the existence of a more or less pronounced epidemic are significant data. Löffler bacilli may not infrequently be found in the pharynx even when there is no membrane. When the pharynx is clean, it is at times possible by depressing the root of the tongue to find a membrane on the epiglottis or at the entrance to the larynx. When it is possible to make a laryngoscopic examination, even if only a momentary glimpse is obtained, a diagnosis may sometimes be made. On the other hand, it must be admitted that this method of examination so disturbing to the children, already anxious on account of the dyspnœa, is only necessary in a small percentage of cases, and when the stenosis is very marked it is counterindicated, and the surgeon must be satisfied with a probability until tracheotomy has been performed, which will enable him to make a quiet examination. The results of statistics justify the surgeon in considering any case of acute stenosis of the larynx in childhood to be of diphtheritic origin until the contrary is proved by more accurate examination, provided the history does not give definite information in favor of some other cause (foreign body). When the history is uncertain, it may be difficult to distinguish the condition from the picture produced by aspiration of foreign bodies. Mistakes have been made in both directions. There are a number of acute inflammatory processes that produce stenosis, such as laryngitis catarrhalis (pseudocroup), phlegmonosa, œdema, and perichondritis. Tumors, for instance, papilloma, and extralaryngeal obstruction, such as retropharyngeal abscesses, may have a similar effect. In adults it is easier to make an error in diagnosis in croupous laryngeal tracheitis, because there is usually no stenosis of the larynx, and especially because the physician is not apt to think of the condition. The laryngeal mirror is of great value in cases of this sort.

Treatment.—No one will dispute that tracheotomy may be indicated at any time in the course of croupous diphtheritic laryngitis, so that there remains only to be discussed the time for operation, and what may be expected from it. Tracheotomy below the obstruction removes instantaneously the signs of stenosis and enables the patient to exist until the disease subsides. The pathological process is not influenced, and extension to the finer air-tubes too often negatives the immediate result of the operation. The influence on the circulation and on complicating diseases of the lung is favorable, inasmuch as they are usually secondary to the stenosis. Rauchfuss maintains that tracheotomy done at the right time is the best prophylactic against bronchopneumonia.

The prognosis of tracheotomy depends on numerous factors. First of all, the character of the epidemic is important. The occurrence of many septic cases makes the statistics worse, and if the bacterium is possessed of great virulence, many patients will succumb to descending croup. Toward the end of an epidemic the prognosis after operation is often much better.

The statistics of the Parisian children's hospitals illustrate this fact, for the percentage of recoveries after tracheotomy in croup varied in the years 1851 to 1875 between 13 and 45 per cent.

Generally speaking, the danger to life increases in proportion to the extent of mucous membrane involved. Cases with simultaneous involvement of the pharynx are more disastrous than when the larynx alone is affected. The prognostic significance of extension to the trachea and bronchi was made evident by Krönlein, who compared patients with tracheotomy whose respiration became perfectly free immediately (66.1 per cent. of deaths) and those where this was not the case (91.3 per cent.). Coughing up of extensive bronchial casts is an ominous sign, and although the respiration is momentarily improved, most of these cases die.

The statistics collected by Rose illustrate the relation of the involved area to the prognosis:

	Per cent.
Of 180 tracheotomies, with disease of the larynx alone, recovered . . .	52.2
Of 946 tracheotomies, with disease of the larynx and pharynx, recovered	28.2
Of 242 tracheotomies, with laryngobronchial croup, recovered	31.9
Of 1331 tracheotomies, with diphtheria of the pharynx, and laryngobronchial croup, recovery	20.4

The time at which tracheotomy is performed is of great significance in determining the fate of the patient. If the stage of asphyxia has been reached, the prognosis becomes worse from hour to hour. It is well known that an operation performed toward the end of the third stage may allow the vital spark to flare up once more, but that the patient usually succumbs after several hours to the damage done by prolonged asphyxia. It is nevertheless important to bear the exception in mind, and to remember that tracheotomy has at times saved life when respiration had ceased and no pulse could be felt. The author will mention the figures of Hirsch and of v. Bergmann's clinic of the various statistics that show the influence of the duration of the disease on the results of tracheotomy. There are 2658 cases. From the first to the ninth day of the disease the death-rate after tracheotomy increased from 45.3 to 82.1 per cent. The same relation was present when patients were taken into the clinic in an advanced stage of the disease, and not operated upon, for the death-rate increased from 18.3 to 81.6 per cent.

The age of the patient is of great prognostic importance according to various authors. During the first year of life the prognosis is almost absolutely fatal, in the second it is still unfavorable, and improves progressively from the third to the tenth. Hirsch found the mortality in the first year of life to be 98 per cent.; in the second, 92.5 per cent.; from the third to the tenth it diminished from 71.6 to 42.3 per cent., and gradually increased from this age to 80 per cent. in adults. Trendelenburg claims that this is because adults with diphtheria rarely are obliged to have tracheotomy performed (13.9 per cent., Hirsch). The dyspnœa is as a rule due to bronchial croup involving the finer tubes, and is not much influenced by tracheotomy. The prognosis in those not operated upon during the first year of life is worse, and even if only a few of the children are saved, these few justify the operation. G. Fischer was able to save 16 per cent. of those operated upon in the first year of life.

The cause of death after tracheotomy is practically the same as in those not operated on, except in the cases of suffocation due to stenoses high up. The danger of operation is insignificant compared with that of the disease. Accidents or mistakes during the operation and incidental infection of the wound, diphtheritic or septic, are untoward events that cannot at times be avoided. Ulceration of the trachea and hemorrhage, necrosis of cartilage, stenosis, and fistulæ might also be mentioned as after-effects. Some observers claim that the tracheotomy-wound becomes infected in more than half of the cases. The wound becomes covered with a whitish deposit, later changing to a dirty gray, and in severe cases extensive gangrene of the neighborhood may follow. The surrounding parts become œdematous, and a sharply outlined inflammatory region surrounds the gangrenous margins of the wound; this inflammation may extend onto the chest. The tissues slough, and the anterior tracheal wall may become necrotic over a considerable area. These severe conditions, with suppuration extending to the mediastinum, are more liable to develop after tracheotomy inferior than after tracheotomy superior. No treatment is of avail. In less severe cases antiseptic measures may overcome the infection. The technic of the operation and the subsequent treatment may be of influence in preventing these complications. It is self-evident that a well-appointed hospital with trained attendants and the constant attention of a physician offers far more favorable conditions than are to be found in a private house. Statistics emphasize this fact, and parents should always be advised earnestly to allow children with diphtheria to be removed to a hospital.

Considering the variety of conditions prevailing in any individual epidemic, the mortality following tracheotomy is only of value when the figures cover a long period. Monti found the mortality in 1887 to be 73.3 per cent. of 12,736 cases; Lovett and Munro, 72 per cent. of 21,833 cases; and Siegert (1890 to 1893), 58.6 per cent. of 10,815 cases.

Behring's serum treatment has effected a marked change in the prognosis of tracheotomy in diphtheria. The specific influence of this method has been shown beyond doubt by experience extending over more than seven years. The advantages of serum treatment are rapid improvement of the general condition and fever, prompt cessation of the local process, and rapid separation of the membrane. Stenosis of the larynx is avoided or made to disappear when present. Diphtheria [illegible] the removed [illegible] in [illegible] treat- [illegible] in 1895 to [illegible], only 15 [illegible] dropped from [illegible] per cent. [illegible] after [illegible] taken [illegible], and the [illegible].

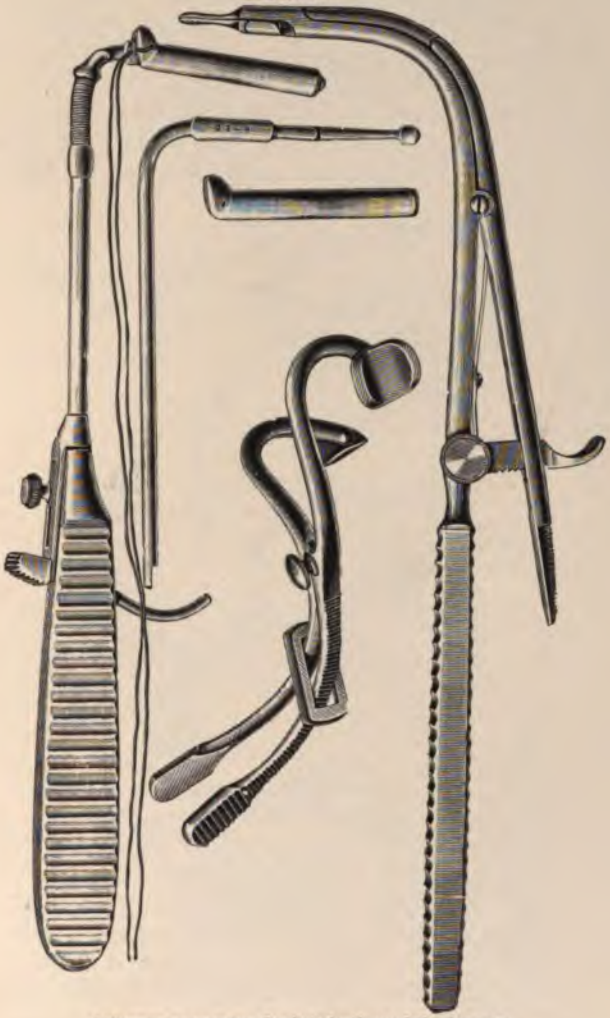
[illegible] the symptoms of [illegible] are fol- [illegible]. It can only [illegible] or even [illegible] organism is [illegible] lung formed. [illegible] and pulmo- [illegible] when there [illegible] the above [illegible] of life be [illegible]. In cases of this [illegible] the situ- [illegible] slight, trache- [illegible]. In some cases the [illegible] in others it may [illegible] or not. When [illegible] should watch [illegible] to the hospital, [illegible] of trans- [illegible] the stenosis will [illegible] tracheotomy may be [illegible] this expectant atti- [illegible] serum as soon [illegible] much and wait for results. [illegible] formerly would have [illegible] waiting. The stenosis [illegible] seen by v. Ranke after [illegible] per cent. [illegible] Bokai's cases, 38 per cent. of [illegible] per cent. [illegible] Sonntag's. Siegert claims that [illegible] operative cases is 4[illegible] per cent. since 1894.

[illegible] OF THE LARYNX.—This method was recommended [illegible] and has many advocates.

Apparatus and Technique.—The principle of the procedure consists [illegible] introduction of a tube through the mouth into the larynx. This [illegible] shaped to correspond with the anatomical peculiarities of the larynx.

O'Dwyer's apparatus, which has from time to time been modified and improved by himself and others, consists of a mouth-gag, a set of six tubes, an introducer, an extractor, and a scale for determining the size of the tube that corresponds to the age of the patient.

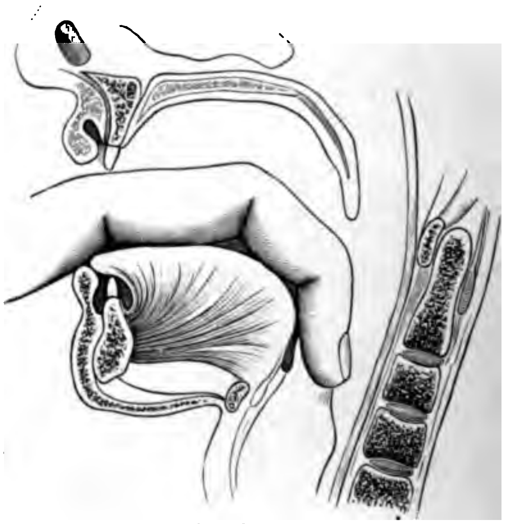
Fig. 52.



O'Dwyer apparatus for intubation of the larynx.

The tubes are of gilded bronze, and are rather heavy to prevent being coughed up. The bulging of the middle portion serves the same purpose and lies below the glottis. Of late corrugated hard-rubber tubes have been recommended. The transverse section is oval, because round tubes are apt to produce sloughing of the vocal cords. The upper end has a head which spreads sidewise and posteriorly and rests on the false cords and on the interarytenoid region. The head has a small hole in the side for a string which prevents the tube from slipping while being introduced. The tube is joined to the introducer by means of an obturator fitting accurately into the canula and possessing a small knob. The size and shape of the introducer are illustrated in Fig. 52. The tube is removed from the obturator by means of two small arms that are pushed forward by means of the finger. This extractor and the method of using it are sufficiently illustrated in Fig. 52. The child is held in the lap of the nurse, and an assistant bends the head of the child somewhat backward (some prefer to operate with the patient lying down). A self-retaining mouth-gag is introduced as far back as possible and the left forefinger inserted behind the epiglottis, which is held forward with the base of the tongue. Force should not be used. It is best to pass over the posterior surface of the epiglottis so as to avoid the œsophagus. After the tube has been successfully placed the obturator is removed, while the forefinger keeps the canula in place or pushes it down as far as it belongs. O'Dwyer sometimes removes the thread, while others prefer to leave it in place and fasten it around the ear or to the cheek by means of adhesive plaster, so as to use it when extracting the tube. It must not be under tension, because the aryteno-epiglottidean folds or the angle of the mouth will be apt to slough. The attacks of coughing that follow intubation may continue five to fifteen minutes or longer, and be repeated after an interval.

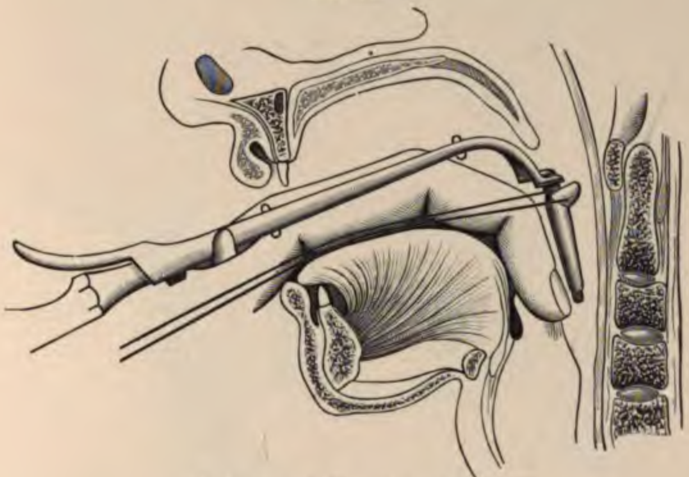
FIG. 53.



Fixation of the larynx. (Lejars.)

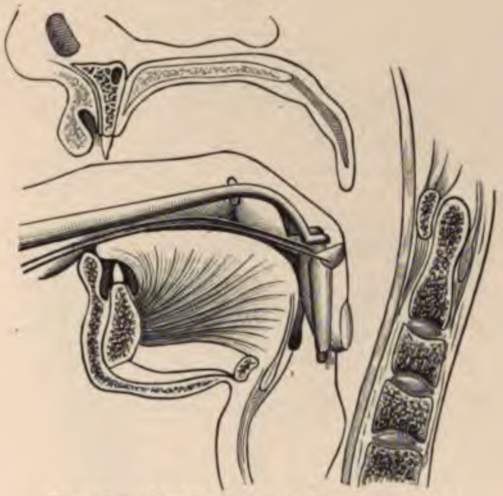
It is generally said that it is more difficult to extract the tube than to insert it. The preparations are the same. Of late Trumpp has called attention to the fact that if a short tube is used, it may be removed without an instrument or thread simply by exerting a little pressure forward and upward from behind on the trachea at the lower end of the tube. Baginsky recommends this method, and Bayeaux obtains the same result by lateral pressure. Intubation in the hands of a skilful operator should be performed in less than a minute. It is well to practise on the cadaver to obtain the necessary skill.

FIG. 54.



The tube in the pharynx. (Lejars.)

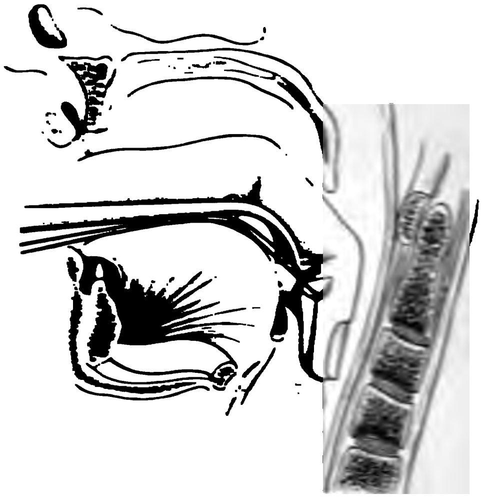
FIG. 55.



The tube guided by the index finger. (Lejars.)

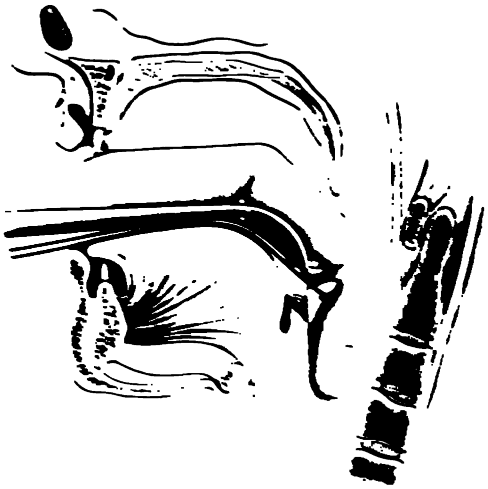
Attention has been called to a number of disadvantages associated with this new procedure. These objections are based largely on actually [illegible] conditions, which have led numerous operators to reject the method. On the other hand, advocates of the method have endeavored to [illegible] these disadvantages or to prove that their significance has

FIG. 56.



The tube penetrates the larynx. (Lejars.)

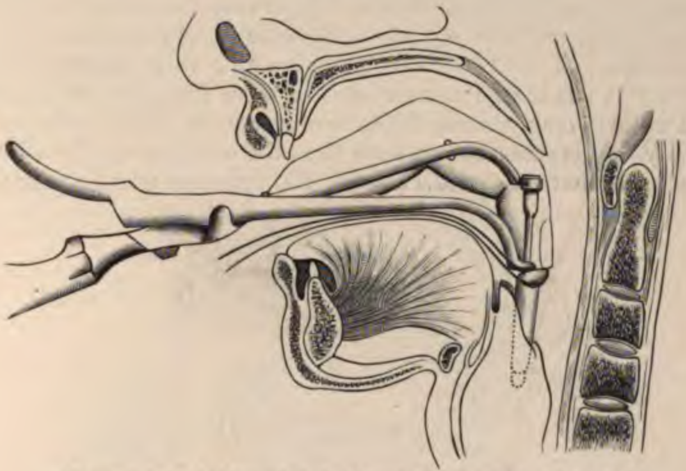
FIG. 57.



[illegible]

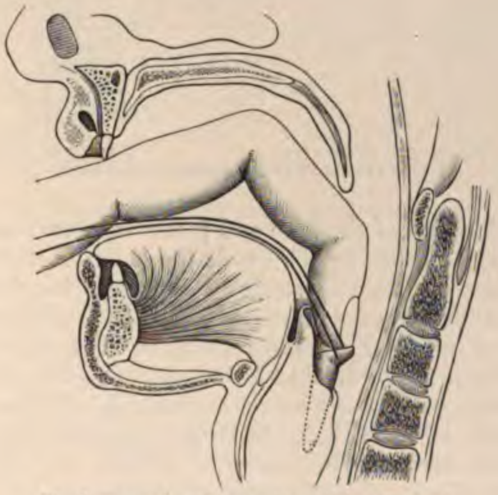
[illegible] undesirable results as [illegible] the introduction of [illegible] trachea, asphyxia from accumulation of secretions in the tube, and finally injuries. The latter are inflicted more frequently when using the extractor than when introducing the tube. Extensive emphysema sometimes follows an injury of this sort. The unavoidable results are more important. It is extremely uncommon to have the membranes separate off and be crumpled up, especially if short tubes are used. Baer found this condition once in 74 cases. In some cases the tube does not reach to the obstruction, or it is impossible to introduce the same on account of

FIG. 58.



The stem is withdrawn while the finger fixes the tube. (Lejars.)

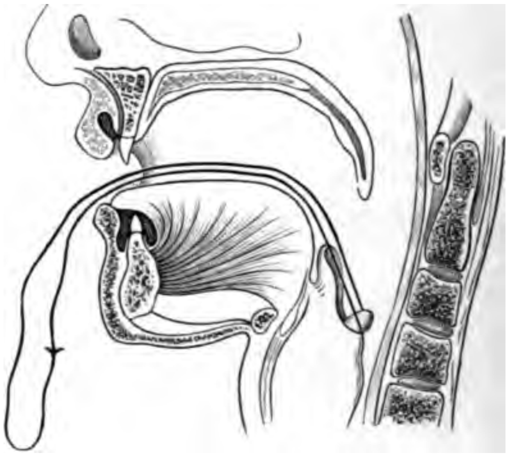
FIG. 59.



The finger pushes the tube into place. (Lejars.)

marked œdema at the entrance of the larynx. In cases of this sort a quick tracheotomy is the only way to save the patient. It is not uncommon to have the tube clogged by a membrane or to have the canula coughed up, or to have the patient vomit during intubation. Sometimes quite large pieces of membrane may pass through the tube. (Baer, v. Bókai.) In other cases the tube becomes clogged and coughing out tube with membrane temporarily improves the condition. It is dangerous to have a plugged-up tube remain *in situ*. The only safe procedure is to remove it quickly, and with reference to this emergency it has been recommended to leave the guide-thread, for by its aid a nurse may remove the tube any moment. It is not considered especially disadvantageous to have the tube coughed up, for oftentimes this indicates that the stenosis is less. Reintubation may be unnecessary.

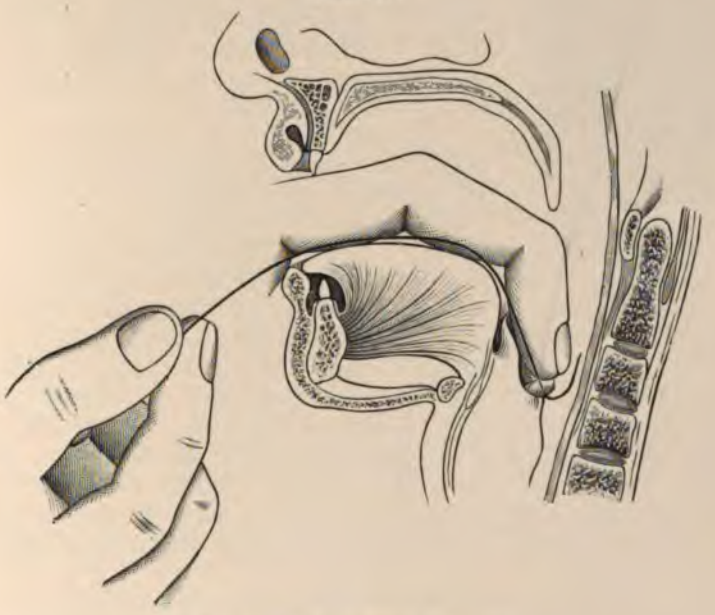
FIG. 60.



The tube in its proper position. (Lejars.)

Repeated coughing up of the tube and persistent stenosis render tracheotomy necessary. By tying the hands the children may be prevented from removing the canula themselves. A physician must, of course, reintroduce the tube, a marked disadvantage of the method, because it demands the presence of a trained hand, not only on account of the accidents above mentioned, but also because the tube may have to be removed at any time for the purpose of cleaning. It has been generally emphasized and recognized by O'Dwyer himself that difficulty in swallowing is a distinct disadvantage. Fluids are apt to enter the canula and give rise to violent attacks of coughing. The dread of pain and the attacks of coughing cause the patient to refuse food. It has been recommended to give semisolid food with the patient in the horizontal position, and v. Muralt and O'Dwyer, by diminishing the size of the top of the tube, have improved the conditions necessary for swallowing. When the stenosis is slight, some authors recommend removal of the tube while feeding, but this advice is of uncertain value because of the danger of vomiting when the instrument is subsequently introduced, and because it is by no means a matter of indifference how many times the operation is repeated. Autopsy reports after intubation do not mention deglutition pneumonia. The difficulties in feeding constitute a grave danger when lasting for some time, for the children emaciate and secondary tracheotomy does not save life, although it may improve the condition temporarily. As regards pneumonia, there seems to be considerable difference of opinion. Some have observed that it occurs frequently after intubation (Wiederhofer, Van Nes, Schwalbe), and claim that insufficient expectoration and deficient supply of air are responsible; others are of the opinion that the conditions in this respect are not materially worse than after tracheotomy. Van Nes deduces from his experience that pneumonia is a counterindication to intubation or is a direct indication for immediate secondary tracheotomy. The fact that a stage of apnœa never follows intubation is an indication that air is not so freely supplied to the lung through a tube as through a tracheotomy canula.

FIG. 61.

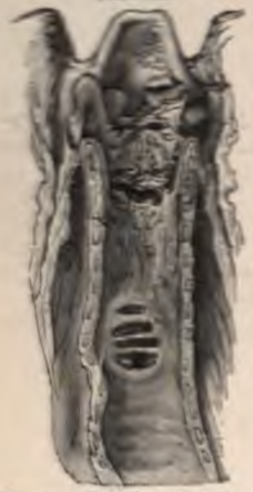


Withdrawal of the thread. (Lejars.)

The ulcers are apt to occur near the upper end of the tube, on the anterior surface of the trachea, or in the region of the cricoid cartilages where the tube bulges. The character of the epidemic is of manifest importance in this direction, otherwise it would be hardly conceivable that such different results could be obtained in different cities.

Baer reports 1 case of pressure-necrosis out of 24 observations. Van Nes mentions 2 out of 67 cases, whereas Ganghofer claims that it is frequently found on autopsy, and Ranke states that it is not an uncommon condition. Variot reports that it occurs in one-third of the cases, and even as enthusiastic an advocate of intubation as Trumpp acknowledges that the danger of pressure-ulcers is a great disadvantage. On account of this danger Wiederhofer, and of late several other surgeons who intubate, recommend secondary tracheotomy when the stenosis has not improved after five days. Individual cases in which the tube has remained for months without annoyance do not affect this rule.

Fig. 62.



Pressure-ulcer due to intubation. (Baginsky.)

The peritracheal abscesses described by Oppenheimer that develop from pressure-ulcers also represent a great drawback to the method. They are a great danger to the life of the patient. These ulcers are closely related to the stenosis produced by scars, which, however, according to most authors, is rare. Schrötter mentions that Kolisko observed this condition quite frequently in the region of the cricoid cartilage, secondary to perichondritis from ulcers. König (Pels-Leusden) has reported several cases of severe stenosis with extensive lesions in the laryngotracheal tube. A further disadvantage of intubation is the impossibility of attacking the trachea itself. Although the results in this class of cases are not brilliant, even with tracheotomy, nevertheless a few cases have been saved by introducing a catheter through a tracheotomy-wound and aspirating the membranes.

The indications for secondary tracheotomy are continued stenosis after intubation, repeated coughing up of the tube, pneumonia, difficulty in feeding, ulcers, perichondritis, cicatricial stenosis, and finally suffocation due to plugging of the tube, provided the guide-thread has been torn off and the tube cannot be removed by external pressure, or when the breathing does not improve after removal. In the latter case it is dangerous to try the extubator because it increases the danger of suffocation, and even if successful does not guarantee removal of the obstruction, so that valuable time may be lost.

The prognosis of secondary tracheotomy is bad, principally because the cases in which it is done are unfavorable, and because it is delayed too long. Siegert demonstrated statistically that in hospitals where primary intubation is the rule the results are better the more frequent and the sooner secondary tracheotomy is performed.

The following are the advantages of intubation as compared with tracheotomy:

I. The dangers of tracheotomy as an operation are avoided, therefore diphtheria of the wound, hemorrhage, and subsequent stenosis, although intubation does not prevent the development of severe stenosis and other after-effects.

2. There is a greater readiness on the part of patients to submit to this procedure.
3. An anæsthetic need not be used, neither is a trained assistant necessary. If the latter is dispensed with, O'Dwyer's rule to be always ready for tracheotomy is also disregarded.
4. The rapid technic.
5. Utilization of the upper air-passages for normal warming and moistening of the air, thus guarding against drying of the secretion and damage to the deeper-seated air-passages. After tracheotomy an endeavor can be made to imitate this function of the nose and pharynx by artificial means.
6. Shorter convalescence—that is, up to the time that the canula can be removed.

After the canula has been removed in cases in which tracheotomy has been performed the difficulty with the wound can no longer be considered part of the primary condition. At times the tube is expectorated within a few hours and has to be reintroduced. The tube should be changed, provided no disturbance has arisen, after twenty-four to forty-eight hours; the number of times it is necessary to reintubate in any individual case varies, but, generally speaking, it increases with the length of time it is necessary to leave the tube *in situ*.

The statistics of v. Bókai show that the tube was finally removed in 80.8 per cent. of 479 cases within the first one hundred and twenty hours. The average duration is usually four to five days; according to v. Bókai, seventy-nine hours. It is rare to be obliged to leave a tube in place more than ten days. It will be seen later that in cases of tracheotomy one cannot remove the canula until a much later date. The following conditions are counterindications to intubation even in the opinion of its most ardent advocates:

1. Complete occlusion of the nasopharyngeal cavity by swelling of membranes.
2. Marked œdema of the entrance to the larynx.
3. The presence of a retropharyngeal abscess.
4. Asphyxia on entrance to the hospital.

Other writers, such as Schlatter and Van Nes, with whom the author agrees, are of the opinion that extensive involvement of the pharynx is a counterindication, because the vulnerability of the diseased mucous membrane renders intubation no longer bloodless. This is especially to be emphasized, because severe pharyngeal diphtheria tends to extend downward. Those cases that show evidence of involvement of the deeper air-passages are also to be excluded from intubation, so that the cases suited for intubation are mainly those in which the larynx alone is involved. In practice this indication can only be complied with when it is possible to ascertain definitely the region involved. The error in judgment is oftentimes evident from the unsatisfactory results following intubation, and in these cases tracheotomy is to be performed immediately. The fact that numerous cases of tracheobronchial croup have been cured with intubation must not lead the surgeon astray. When the process giving rise to stenosis extends beyond the tube, chance plays too great a part for a conscientious surgeon to take any risk. This latter consideration and the recognized difficulties of after-treatment have always deterred the author from intubing diphtheritic children outside of a hospital in spite of the enthusiasm of some authors. He has never recognized that the condition is one of intubation *versus* tracheotomy, for experience to date shows that both operations are justifiable, and any attempt to compare the superiority of one or the other method from the percentage of mortality is futile. The more cases are reported, the less the difference in the mortality of the two operations.

MacNaughton and Madden found that the percentage of recoveries in 5546 cases collected up to 1892 was 30.5. Gillet found it to be 29.2 of 8299 cases of intubation and 30 in 1599 cases in which tracheotomy had been performed. v. Ranke found that recovery took place in 39 per cent. of 1324 cases of intubation in primary diphtheria, and in 38.9 per cent. of 1118 tracheotomies. Siegert has shown that in the preserum period the mortality was 64.4 per cent. and 58.6 after intubation and tracheotomy respectively. It must be taken into consideration when comparing these figures that the mortality of tracheotomy is influenced in a large majority of cases by the severity of the attack—that is, in cases in which intubation is counterindicated, even when used in a most liberal way. It should furthermore be remembered that of those intubated about one-fifth have to be subsequently operated upon, and inasmuch as tracheotomy is more likely to save life in these cases the sooner it is done, the conclusion, according to the author's opinion, seems justified that tracheotomy is the more valuable procedure in connection with diphtheritic stenosis. If the percentage of mortality alone were considered, intubation would have to be abandoned entirely. The latter method, however, is said to give better results in the early years of life according to American statistics. Baer as well as v. Ranke is of this opinion, whereas Van Nes, as the result of his experience, holds that primary tracheotomy is distinctly indicated in the first two years of life.

The benefit of serum treatment has naturally been mutual both to intubation and tracheotomy. In both cases the relation of mortality to recovery has been reversed compared with the anteserum period. Siegert showed that the percentage of deaths in 11,104 tracheotomies from 1895 to 1900 was 34.29, whereas in hospitals where intubation was used 34.27 per cent. died. These results in intubation, however, were reached only with the aid of primary and secondary intubation. The length of time it is necessary to leave a tube in place is said to be much shorter since the use of serum. Soltmann claims the average time to have decreased from one hundred to fifty-eight hours, and according to v. Bókai from seventy-nine to sixty-one hours.

The more specific treatment influences the death-rate by no longer permitting the diphtheritic process itself to be the sole controlling factor, the more the danger of any method of operation becomes evident, and in this connection it is interesting to note that in American statistics of 138 deaths after intubation 6—*i. e.*, 4.4 per cent.—were caused by suffocation (3 times due to plugging and 3 times to coughing up of the tube). The fact that diphtheria of the wound, as shown by Krönlein and others, does not occur with serum treatment has removed the most serious objection against tracheotomy. The author therefore does not agree that serum treatment has rendered the conditions more favorable to intubation than to tracheotomy, and it is not surprising that there are still physicians who prefer tracheotomy to intubation as an operative procedure in diphtheritic stenosis (v. Bókai) if the material at hand be examined critically. On the other hand, the author must agree with Schlatter that intubation may lead to recovery in a shorter time and in a less aggressive manner in a number of carefully selected cases, but primary intubation on principle is to be condemned.

Œdema of the Larynx, Laryngitis Submucosa.—Œdema of the larynx is in the majority of cases due to some inflammatory process. This fact alone would justify considering the subject under inflammatory conditions, which, moreover, is absolutely necessary if it be called to mind that all sorts of infiltrations of the mucosa or submucosa, serous and even purulent, have been included in the collective term œdema of the glottis since Bayle created the phrase œdème de la glotte.

Repeated attempts have been made to eliminate the confusion that has arisen by laying so much stress on one symptom. Küttner claims that the term œdema of the larynx should only apply to those processes in which active irritation in the larynx is absent, whereas all diseases in which infiltration is due to local inflammatory process he includes in the term laryngitis submucosa. Any sharp differentiation such as this based on pure etiological conditions will be extremely difficult in practice.

Non-inflammatory œdema of the larynx, which will be considered here because it may become so extensive as to render tracheotomy necessary, may be, according to v. Ziemssen, part of the clinical picture of general hydrops in acute or chronic affections of the kidney, cachexia of malaria, etc., or the result of congestion secondary to disease of the heart, emphysema of the lung, etc., or may be due to some local obstruction to the flow of venous blood in the larynx (tumors of the neck and mediastinum, thyroid enlargements, glandular tumors, and aneurisms of the aorta). The author had an opportunity to observe a case of œdema of the larynx following congestion produced by the pressure of a goitre the size of a child's head and situated in front of the pericardium.

The internal use of potassium iodide sometimes results in acute œdema of the larynx, probably on account of idiosyncrasy. In the first case observed, Fenwick's patient, as well as in cases observed later, tracheotomy was necessary, while in other cases tracheotomy was done too late. This œdema may diminish rapidly if the drug is omitted. It has not been decided what the pathology of this œdema is, whether of inflammatory or nervous origin. The same applies to Strübing's angioneurotic œdema.

The inflammatory infiltration included by Küttner in the term laryngitis submucosa corresponds only partly to the anatomical idea of œdema. He differentiates three stages: the œdematous stage, the plastic stage, and the suppurative stage, developing one after the other.

Etiologically these processes may be divided into two groups: those due to local affections of the larynx and its vicinity, the symptomatic and transmitted œdema of Hajek; and distinct infective processes establishing themselves, either primarily in the submucosa of the larynx or as metastases in the course of some infectious disease elsewhere. The first group comprises the cases of injury to the air-passages by some external force, by foreign bodies, by chemicals or heat, and by diphtheritic processes. To these must be added acute catarrh, perichondritis laryngea, tuberculous, syphilitic, and carcinomatous ulcerations, and finally the sources of secondary œdema, such as suppuration of the floor of the mouth, of the base of the tongue, and of the pharynx (retropharyngeal abscesses), in the connective tissue of the neck, and inflammations of the salivary glands, and strumitis.

Simple catarrhal laryngitis, especially if it has not been properly treated, has repeatedly given rise to life-endangering stenosis (laryngitis acutissima, v. Ziemssen). König was obliged to perform tracheotomy in an adult in a case of this sort, and v. Bruns had a like experience. It must be assumed that the submucosa is involved in this condition, for the mucous membrane alone, the thickness of which is measured in micromillimetres only, would hardly be able to swell sufficiently to produce these symptoms. The anatomical and physiological conditions of an infant's larynx are responsible for the fact that signs of stenosis are much more common in these patients than in adults during the course of catarrhal inflammations (pseudocroup, catarrhal croup). The inflammatory œdema of the second group is observed in the course of septic, pyæmic, general infection in the course of ulcerative endocarditis, erysipelas of the face, typhoid, variola, scarlatina, measles, or it is the result of primary erysipelas of the larynx or suppuration in the larynx the primary cause of which is unknown.

The differences in etiology render it easily understood how the anatomical picture may vary extremely. The infiltration varies from a simple serous transudation with few cells to purulent suppurative saturation of the tissues. The so-called plastic infiltration is an intervening stage of gelatinous consistency. When the region is incised, no fluid runs out as in the two above-mentioned conditions. The mucous membrane is stretched tightly over the œdematous area, which is pale if the œdema is simple, but in inflammatory infiltration is more or less reddened. The submucous swelling may affect the entire larynx or be limited to individual portions. The anatomical relations of the submucosa and the seat of primary irritation have a certain influence on localization, so that diffuse types extend by no means uniformly over all the structures of the larynx. The aryteno-epiglottidean folds, rich in loose connective tissue, may increase enormously in size. The false cords and the subcordal tissues are also prone to œdema, whereas the true vocal cords, in which there is no submucous tissue proper, are rarely the seat of sufficient infiltration to give rise to stenosis. Œdema of the trachea itself is also rare. The artificial injections of the submucosa of Hajek have been of valuable aid in recognizing the course which inflammatory œdema follows anatomically. His results correspond absolutely to clinical experience. Diffuse swelling of the subcordal tissue is usually responsible for the symptoms of stenosis in catarrh of children (laryngitis hypoglottica). Perichondritis is not infrequently an associated condition, although œdema of the entrance to the larynx only is the chief symptom when the condition is secondary to some neighboring infectious process and in idiopathic suppuration and erysipelas of the larynx itself.

An attempt to differentiate between erysipelas and infection on the basis of anatomical conditions is much more difficult in the larynx than in the skin because the thin mucosa changes very gradually to submucosa. It is relatively common to find mixed forms of pure œdematous swelling and purulent infiltration of the submucosa. If Virchow's statement is accepted, that erysipelas of the larynx usually causes only œdema, most of the cases reported in literature do not deserve the name. Gerber has recently laid particular stress on the pathological and anatomical conditions. If the inflammation, as is not infrequently the case, is complicated with similar processes in the neighborhood, it may be difficult in any individual case to determine the primary focus. Localized inflammatory swelling of the submucosa gives rise to circumscribed abscesses of the larynx, a condition most frequently observed in the region of the upper surface of the epiglottis, rarely on the aryteno-epiglottidean folds or false cords, and very exceptionally on the vocal cords. Naturally, the œdema around any such focus may be very extensive.

Symptoms.—The symptoms of œdema of the glottis are due, first of all, to mechanical diminution in the lumen of the larynx with secondary dyspnœa. In the most common type of œdema—*i. e.*, œdema of the aryteno-epiglottidean folds—the dyspnœa is at first at least inspiratory, because of the valve-like aspiration that presses the swollen folds against each other. The changes in voice are also mechanical, but have nothing characteristic (harsh, hoarseness). In inflammatory œdema pain is present, the intensity of which corresponds usually to the acuteness of the process. The pain may be constant, and is especially aggravated by swallowing. The amount of fever and other constitutional disturbance depends largely on the primary cause.

It is of practical interest that the submucous infiltration may develop very rapidly, even in cases in which no symptoms referable to the larynx are noted or in which the signs of inflammatory irritation are very slight. Sometimes some external condition or some functional irritation precipitates the acute attack, which may be followed rapidly by death from suffocation (overuse of the voice). It is probable in cases of this sort that the slight œdema was not noticed because it produced no symptoms. Traumatic œdema is especially feared on this account, although the same conditions occur in inflammatory processes. Gerber claims that the rapid appearance and disappearance of œdema are especially characteristic of erysipelas, and according to his views the differential diagnosis between erysipelas and acute infectious inflammation is based largely on this fact. In the former condition dyspnœa is the predominating symptom, and recovery usually takes place if the obstruction to respiration is removed, whereas in the latter disease marked symptoms of stenosis are rarely present and the patient succumbs to the general septic infection in the course of a few days or weeks without increase of the laryngeal symptoms. Neither the complications resulting from extension of erysipelas downward (bronchitis, pneumonia) nor those due to metastatic extension of the virus will be considered here.

Diagnosis.—The diagnosis of œdema of the larynx is easy if an examination with a mirror can be made. This method gives information as to the degree and extent of the infiltration. If the condition is aggravated, then the swollen aryteno-epiglottidean folds prevent viewing the interior of the larynx, and sometimes a uniformly swollen epiglottis is all that can be seen. A subglottic swelling will show as two longitudinal folds below the vocal cords. The mirror may also give information as to the nature of the infiltration and its probable course. Pus can be diagnosticated with certainty only when it shows yellow, and œdema low down may never be recognized without the laryngoscope, whereas infiltration of the epiglottis and of the arytenoid folds may oftentimes be detected if the base of the tongue is forcibly depressed or by palpation with a finger, although the latter method of examination has been denounced by laryngologists as brutal and dangerous. Sometimes the history will reveal the fact that the stenosis is developing with more or less rapidity, and will then justify a tentative diagnosis of œdema of the larynx. In severe cases it is sufficient to have recognized the danger of suffocation, after the removal of which an accurate diagnosis may be made at leisure. The advantage of a systematic laryngoscopic examination in any case of difficulty in the throat is that it may detect œdema of the glottis even when slight.

Prognosis.—Statistics show that the prognosis of œdematous laryngitis is very unfavorable. Sestier reports 158 fatal cases, 30 of which had tracheotomy, of 213 cases of œdema of the glottis. It should be taken into consideration that slight cases are usually not observed, and in the prelaryngoscopic period escaped detection. These figures prove, however, that when œdema dominates the clinical picture in an affection of the larynx the patient's life is seriously endangered.

Treatment.—The treatment is as complicated as the etiology, and inasmuch as œdema is usually secondary, it would seem more rational, first of all, to prevent infiltration of the larynx by removing the primary cause. Various medical and surgical measures, both extralaryngeal and intralaryngeal, may have to be resorted to, such as opening of abscesses in the larynx, excision of tumors, removal of general hydrops by internal medication, and antiphlogistic measures to combat the inflammatory infiltration. Frequent swallowing of small pieces of ice and the use of external poultices have the best effect. The value of astringents is disputed. Scarification of the mucous membrane as recommended by Lisfranc is also of uncertain value. Tobold recommends doing this with a guarded laryngeal knife. The breathing must be carefully watched from the start, and what has been said in connection with diphtheritic stenosis in favor of timely tracheotomy applies here also. Certain dangers of tracheotomy in diphtheria (wound diphtheria) need not be feared, whereas the treacherous œdema of the larynx may lead to disastrous procrastination. v. Ziemssen says that one should never leave a patient with œdema of the larynx, and if no instruments are at hand should perform tracheotomy with a penknife rather than allow the patient to suffocate.

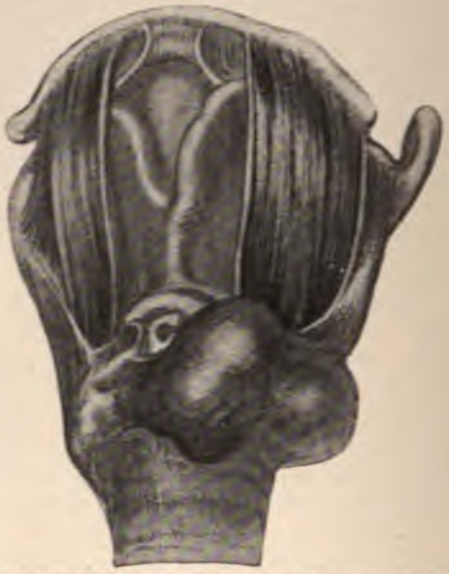
When the conditions are such that there is danger of œdema of the glottis developing, then tracheotomy must be performed as a prophylactic measure. It has been emphasized that intubation is counterindicated when the œdema of the glottis is marked.

Pseudocroup.—There remains to be considered catarrh of the larynx in childhood—*i. e.*, pseudocroup (Guersant)—giving rise to stenosis. The severe cases with œdema are undoubtedly cases of submucous laryngitis, but even in the ordinary cases that differ from the severe ones only in degree it must be supposed that the submucosa has become involved when sufficient swelling arises to produce stenosis.

Symptoms.—The course is usually rather typical. During the day there have been slight catarrhal symptoms; in the early hours of the night the child awakens with an acute attack of suffocation (inspiratory dyspnœa) associated with a rough, barking cough. After a short time the alarming symptoms subside somewhat, and the child falls to sleep again within one or two hours. The next morning there is usually nothing to be noticed except a moderate amount of catarrh. Not infrequently a second attack occurs the second night, but this is usually much lighter, and it is uncommon to have an attack on the third night. The tendency to recur is so characteristic that children that have once been attacked are subsequently liable to have symptoms of stenosis with any attack of catarrh. As a rule, the result is favorable in spite of the alarming beginning. However, several examples of suffocation are reported. Krieg refers to the rapidly diminishing swelling of the mucous membrane of the nose in acute and chronic catarrh as an explanation of the sudden disappearance of the stenosis. He considers that the subcordal tissue is just as liable to shrink as to swell suddenly and produce stenosis, a peculiarity mentioned in the reports of laryngoscopic examinations (laryngitis hypoglottica).

Diagnosis.—The most important differential diagnostic symptom is the sudden appearance of suffocation in pseudocroup, a symptom appearing gradually in stenosis due to diphtheria. The tendency to recur is significant when the attack is not the first, and laryngoscopic examination will show that the subglottic folds are not obscured and that there is no membrane. Although it is usually easy to separate pseudocroup from fibrinous croup because of the typical clinical picture, yet it must be mentioned that in the most difficult cases of stenosis lasting for several days a differential diagnosis may be absolutely impossible.

FIG. 63.



Perichondritis cricoideus with external abscesses. (Türck.)

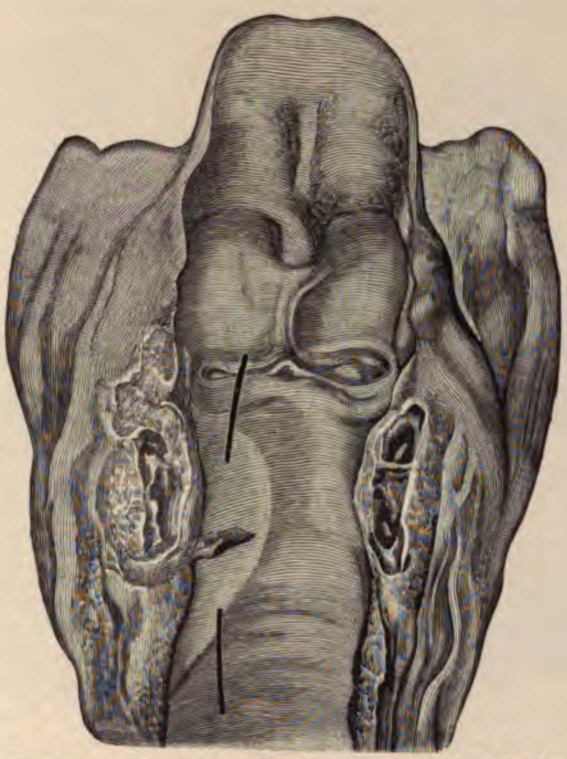
Treatment.—Surgical interference is usually not indicated, although tracheotomy has occasionally been necessary. Of late intubation has been recommended by authors that make use of this method with reserve in diphtheria, and it must be acknowledged that the short duration of a stenosis surely affecting the larynx and the absence of membranes remove most of the above considered objections.

Perichondritis Laryngea.—**Etiology.**—Inflammation of the perichondrium is usually secondary. Ulcerative processes of the mucous membrane (tuberculous, syphilitic, typhoidal, lupous, variola, measles, carcinoma) allow the entrance of pyogenic cocci into the perichondrium ; or the perichondritis is of metastatic origin in the course of some septic disease. Sometimes injury with a sharp or blunt instrument, foreign bodies, or chemical and thermic irritants are the immediate cause. In marantic individuals Dittrich claims that ulcers and subsequent perichondritis may occur as the result of pressure of the posterior wall of the larynx against the vertebral column. Inflammations occurring in the course of typhoid in the same place have been explained in the same way.

In cases of primary perichondritis infection through some unknown focus is responsible, as pointed out by Eppinger. Overexertion and atmospheric conditions may be the cause in exceptional cases.

The anatomical changes in perichondritis are analogous to those of purulent periostitis of bones. The pus separates the perichondrium from the cartilage, and the latter becomes necrotic because deprived of nutrition. The size of the abscess varies according to the time perforation takes place. (Figs. 63 and 64.) In perichondritis secondary to an ulcerative process the abscesses are as a rule not so large as in the primary or metastatic variety. Suppuration takes place on the inner as well as on the external surface of the cartilage, but no sharp separation between perichondritis interna and externa is possible, at least when the condition has existed for any length of time. Partial or complete fistulæ of the larynx result when perforation takes place either into the larynx or pharynx, or externally in both directions. When the suppuration is external, there may be considerable destruction of the soft parts before the abscess ruptures.

Fig. 64.



Same preparation as Fig. 63, cut along the median line behind.

The interior of the abscess contains a cartilage sequestrum representing the entire cartilage (arytenoid) or only a portion of the same. After a sinus has existed for a considerable length of time the sequestrum becomes more and more eroded, and in exceptional cases it may disintegrate entirely. (Figs. 65 and 66.) Sometimes the soft parts and cartilage are thickened even without abscess, a condition usually due to chronic sinus suppuration. This is especially the case in syphilitic perichondritis. After the inflammatory process has healed, the callous thickening of the internal soft tissues and scar-contraction become of practical importance.

FIG. 65.

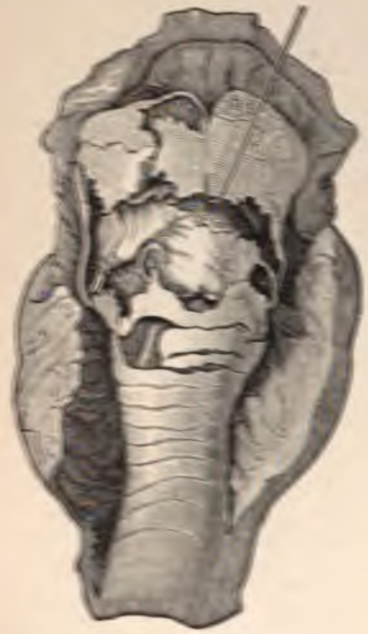
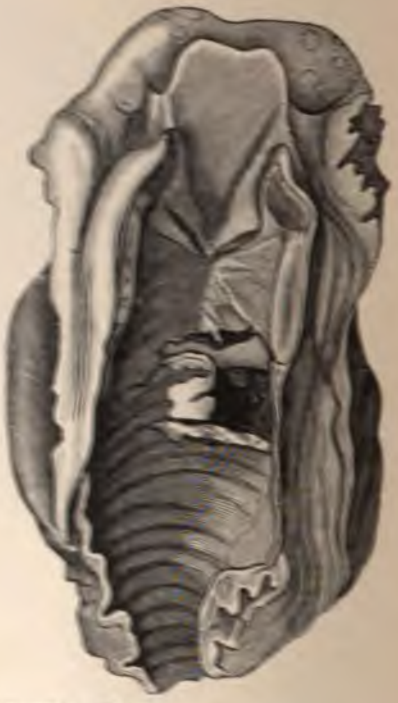


FIG. 66.



Extensive perichondritic necrosis. (Krieg.)

The arytenoid cartilages are most frequently the seat of perichondritis when this is secondary to some ulcerative process. The cricoid may also be involved, but it is rare to see the thyroid affected. Primary and metastatic inflammation are more apt to affect the cricoid cartilage. Analogous processes in the trachea are infrequent, and when present may at times destroy a large portion of the tube. Necrosis generally is the result of operative interference in diphtheria (tracheotomy and intubation). The course of perichondritis varies. In idiopathic cases and in those occurring in connection with infectious diseases the course is acute, whereas inflammation due to syphilitic, tuberculous, or cancerous conditions is generally chronic.

The dangers of perichondritis are due chiefly to mechanical interference with respiration, the lumen of the larynx being encroached upon by an abscess or by the collateral œdema. Rupture, especially while asleep, may be followed by suffocation, owing to aspiration of the pus, and fatal asphyxia has been caused by collapse of the larynx-walls after elimination of a large sequestrum, especially of the cricoid, or following lodgement of a piece of cartilage in the glottis. In the stage of sinus suppuration pneumonic infection may at any time result fatally. Complete obliteration of the lumen may be secondary to scar-contraction, especially after separation of large sequestra, owing to the great thickening of the mucous membrane resulting from the chronic irritation. Throwing off of the arytenoid cartilage does not, as a rule, cause much disturbance, but it does lead to cicatricial fixation of the corresponding vocal cord, which may, however, also be the result of inflammation in and about the crico-arytenoid joints even when there has been no necrosis.

Symptoms and Diagnosis.—Difficulty in swallowing, hoarseness, and dyspnœa are the chief symptoms of perichondritis, and sometimes there is local tenderness. These symptoms are, of course, not sufficient to make a diagnosis. The presence of an external abscess or of one encroaching upon the lumen of the larynx, as shown by laryngoscopic examination, makes the diagnosis more certain. When the cricoid and thyroid are affected, the sublottic space is diminished, and when the body of the cricoid and the arytenoids are involved, the abscess may point in the pharynx. A positive diagnosis is only possible after demonstrating necrosis of cartilage following spontaneous or artificial opening of an abscess. Before this has taken place it may be impossible to differentiate from laryngitis submucosa, especially if the œdema is marked.

Prognosis.—The prognosis of perichondritis as far as life is concerned is always grave, and still worse as far as function is concerned. In the secondary types it is still further affected by the primary disease. Landgraf reports 60 per cent. of recoveries in tracheotomy for perichondritis after typhoid.

Treatment.—As far as early antiphlogistic measures are concerned, Türck states that only temporary relief is to be expected. It need not be emphasized that the indications for tracheotomy at times are urgent, and the necessity for incising an abscess and removing necrotic cartilage is equally self-evident. It goes without saying that in external perichondritis these steps are taken from without, and that internal abscesses are to be opened from within. Whether the latter procedure is always to be recommended is another question. Considering how little information examination with a mirror gives as to the extent of the process, and allowing for the difficulties of operating endolaryngeally, it is difficult to conceive how any treatment that corresponds to generally accepted surgical ideas can be carried out with external opening alone. An intralaryngeal incision removes the momentary danger, except, perhaps, in cases of perichondritis arytenoidea, and changes an acute process to a chronic one, which endangers the life of the patient until the sequestrum has been removed (aspiration pneumonia). Compared with this method, laryngotomy combined with tracheotomy and packing allows of extensive opening of an abscess and early separation of diseased cartilage, and prevents infectious secretion from entering the lungs, and furthermore permits antiseptic treatment of the focus. Then, again, prophylactic measures, such as packing the larynx and passing of laryngeal sounds so as to diminish the danger of secondary stenosis, may be used. Experience has proved that operating upon stenosis of this sort is fruitless. These advantages and the good results obtained in individual cases by external operation (v. Langenbeck, Pieniázek, Küster) seem to justify Schüller's position, who strongly advocates laryngotomy, at least in those cases in which the perichondritis is a more or less independent condition, and not part of some other process in itself fatal. The laryngotomies reported up to the present time were all performed during the stage of sinus suppuration.

Specific Inflammations of the Larynx and Trachea.

Chronic inflammatory processes that demand surgical interference, either primarily or owing to some secondary condition, are usually the result of a specific infection, chief of which is tuberculosis or syphilis.

Exceptionally, chronic infiltration following simple catarrh may produce considerable stenosis, as in laryngitis hypoglottica of children above described, following which there may be more or less permanent swelling. Krieg believes it justifiable to consider many so-called recurrences acute exacerbations of some chronic process. He has reported cases in which stenosis existed for several years, but finally required tracheotomy. In adults analogous conditions are extremely rare. In the majority of cases the infectious nature can be demonstrated, and the experience of the last few years has shown that chorditis vocalis inferior hypertrophica, as described by Gerhardt, if not due to tuberculosis or syphilis, is usually to be considered as laryngoscleroma, as is also Störk's blennorrhœa. Chronic inflammatory hyperplasia of the ventricular mucous membrane, known as prolapsus ventriculi, is exclusively of laryngological interest, although in one of the cases first observed Lefferts's suspicion that the condition might be malignant led to laryngotomy.

Tuberculosis of the Larynx.—Primary disease in this region is rather rare, although a number of autopsies have shown that the larynx alone may be involved. Almost always there is tuberculosis elsewhere, especially in the lungs, and most authors claim that disease of the larynx is almost always secondary. Men are affected two to three times as frequently as women, children very rarely, 2 to 3 per cent. Most cases occur in the third decade of life. As far as the anatomical distribution of tuberculosis of the larynx is concerned, reference will be made to the classical treatise of Scheck. The vocal cords and the posterior wall are most frequently involved, then the aryteno-epiglottidean ligament and the arytenoid cartilage, then the epiglottis, the false cords, and finally the subglottic space. Unilateral disease is noticeably common. Schäffer estimates this to be the case in 50.3 per cent. of the cases. The diseased half of the larynx is said to correspond to the side of the lung chiefly affected. Of 700 cases, Krieg found 49.3 per cent. to be unilateral, and in 91.6 per cent. of these the seat corresponded to the side on which the lung was affected.

The tuberculous infiltration sooner or later becomes ulcerated. There is a tendency to the formation of abundant granulation-tissue, giving rise to stenosis, especially if the primary seat is the vocal cords or the subcordal space. Deep ulcers are of especial interest to the surgeon because secondary perichondritis and inflammatory œdema are frequently associated with these lesions. According to M. Schmidt and others, pyogenic secondary infection is responsible for the secondary complication. It has been mentioned in connection with perichondritis that the arytenoid and cricoid cartilages are most frequently affected, and that the epiglottis may be almost entirely destroyed.

Tuberculous tumors are a rare type of tuberculosis of the larynx. They are found most frequently in Morgagni's pouches, covered with intact epithelium and appearing as polypoid or cauliflower-like excrescences. Miliary tubercles have at times been observed, but are of no diagnostic importance.

Tuberculosis of the trachea without simultaneous involvement of the larynx is rare. Here too infiltration and overgrowth of granulations may lead to stenosis.

Diagnosis.—Little is to be said as far as the diagnosis is concerned. Hoarseness, cough, difficulty in swallowing which may become unbearable if the aditus is considerably involved, finally lead to laryngoscopic examination. The appearance of the ulcer frequently does not make the diagnosis absolute, although unilateral disease is suspicious. Examination of the lung may give valuable information, and the secretion of the ulcer should always be examined for bacilli. According to Fränkel, they are to be found in any tuberculous ulcer of the larynx if the material is taken from the base of the ulcer with a cotton swab or a curette and then examined repeatedly. Tuberculous tumors can be recognized only after microscopical examination of the excised tissue, and even then the diagnosis may be difficult on account of the frequent association of tuberculosis with syphilis or carcinoma.

Prognosis.—The prognosis of tuberculosis of the larynx is unfavorble, although it is not hopeless as formerly claimed. The majority of the patients succumb after a varying length of time, usually to complicating tuberculosis of the lungs, more rarely to affection of the larynx directly (suffocation). Generally speaking, the pulmonary process and the disease in the larynx progress *pari passu*, although exceptions to this rule occur. Permanent cures are uncommon; recurrences are the rule, or the patient succumbs to pulmonary diseases even when the focus in the larynx is cured. As the local lesion heals grave stenosis may develop on account of extensive adhesions in the vicinity of the granulating vocal or false cords (especially the anterior commissure), and later because of scar-contraction. These late sequences, which may give rise to surgical interference, are very few, as will easily be understood.

Treatment.—The treatment of tuberculosis of the larynx will be considered only so far as surgical measures are concerned. It need not be mentioned that the value of general therapeutic measures and internal medication is fully appreciated, for in many cases these alone are indicated. Local treatment, medical as well as surgical, belongs to the field of laryngology in the majority of cases. Lactic acid (30 to 100 per cent.) is the chief medicament used in the treatment of circumscribed ulcers, whereas in extensive lesions and poor general condition its use is counterindicated. In these cases it is well to apply some antiseptic powder, and cocaine, orthoform, and finally morphine may in the last stages diminish the intense pain caused by swallowing.

The question as to the justification of surgical treatment of tuberculosis of the larynx has been much discussed and variously answered since it was so ardently advocated by M. Schmidt and Heryng. If it be taken into consideration that the disease of the larynx can be cured, as has been proved, and that tuberculosis of the lung if not too far advanced may recover, it is difficult to see why foci in the larynx that defy other measures should not be attacked surgically, especially since this mode of procedure has been shown to be successful in tuberculosis of other regions of the body. Of endolaryngeal operations (incision, submucous injections, curetting, electrolysis, galvanocautery), removal of tuberculous tissue by means of a simple or double curette, combined with lactic acid treatment, has become popular in Germany. The technic and the special indications cannot be gone into here, but poor general condition, advanced disease of the lungs, and extensive local lesions are considered counterindications.

Of the extralaryngeal methods, tracheotomy is first to be considered. There is no doubt as to the justification of this step in cases in which the anatomical changes have led to dangerous stenosis. M. Schmidt recommends this operation as a prophylactic measure when there is dangerous disease of the larynx, with difficulty in swallowing, but comparatively good vitality, believing that the laryngeal disease may be favorably influenced by diminishing the functional irritation.

Laryngotomy has been performed for tuberculosis about twenty times, and in a certain number of cases it has been done because of error in diagnosis. The results are not encouraging as yet, and are best in tuberculous tumors. Recurrence and an increase in the pulmonary condition soon mar the pleasure of the initial success. Nevertheless, considerable improvement has been observed in individual cases, and in one case reported by Hopmann the patient followed his occupation as clergyman for eleven years after operation. The number of cases of partial or total excision of the larynx performed in this disease on account of errors in diagnosis is still smaller than the number of laryngotomies reported. A patient of Trendelenburg's, in whom unilateral excision of the larynx had been performed, reported absolutely well for three years. The fact that the indications for extralaryngeal interference in tuberculosis of the larynx are few is due to the peculiarity of the disease, and in any case the lungs must not be extensively involved. On the other hand, it does not seem justifiable to condemn surgical interference entirely, inasmuch as the immediate danger is much less than formerly, and furthermore because primary tuberculosis of the larynx has been cured in this way.

Lupus of the Larynx.—This is classified clinically and anatomically as a separate type of tuberculosis. There are primary and secondary lupus of the larynx. Secondary lupus of the larynx is not so uncommon as formerly assumed. Numerous cases have been reported since the first description by Türck in 1864. Marty collected 81 observations in 1888. Peplau estimates the frequency of secondary involvement of the larynx to be about 6 per cent. The larynx itself is rarely affected primarily. Only 14 cases could be found by Rubinstein in 1896; Peplau has added 4 to this list; and recently Mayer (New York) has added 2 additional cases.

Diagnosis.—Nodular and papillary excrescences, chiefly on the epiglottis and in the region of the aditus laryngis, are characteristic of lupus. Rarely they are seated lower down and associated with small ulcers and scars that not infrequently show minute nodules of recurrence. The course is protracted, corresponding to that of lupus of the skin, and it has been emphasized that there may be marked local changes without much subjective disturbance. Tuberculosis, nodular syphilides, and leprosy have all to be considered in the differential diagnosis. In secondary lupus the condition of the skin will, of course, be a valuable guide. Aside from this, the general physical examination, the results of potassium iodide treatment, and finally microscopical examination of small particles will help decide the question.

Prognosis.—The prognosis is grave. Death is not infrequently due to tuberculosis elsewhere. Symptoms of stenosis may appear in the course of the disease due to lupoid infiltration and excrescences (rarely œdema of the glottis), and later because of scar-contraction, although this form of constriction does not become extreme.

Treatment.—The treatment generally speaking is the same as that for lupus of the skin. Lactic acid has not proved efficient in lupus. Tracheotomy may be necessary at any time.

In a case in v. Bruns' clinic Gare excised the entire aditus laryngis affected by primary lupus through the incision used for pharyngotomy subhyoidea, and obtained temporary alleviation; later stenosis due to scar-tissue developed, and could not be removed by treatment with bougies. Brondgeest reports a cure after pharyngotomy subhyoidea with subsequent laryngotomy, and Rydygier (Langie) after excision of the larynx following error in diagnosis (carcinoma).

Syphilis of the Larynx and Trachea.—This disease may produce local lesions in the larynx as soon as it becomes general. Statements as to the frequency of syphilis of the larynx vary. Gerhardt assumes that the larynx is affected in more than 10 per cent. of all syphilitics, basing this statement on various statistics. The types of syphilis of the larynx occupy the surgeon's attention to a varying degree. The most frequent manifestations, such as catarrh and erythema, do not demand his attention. Condyloma, although much less common, may give rise to dangerous stenosis if not treated in time, an observation that applies in a much greater degree to tertiary syphilitic lesions, such as solitary gummatous nodules, which may be as large as a hazelnut. Sometimes there are groups of smaller nodules, and finally there may be diffuse gummatous infiltration, which is the condition most common. The ulcers occurring at any period are due to disintegration of gummatous infiltration, and may demand surgical attention on account of the secondary phenomena. These ulcers may be associated with acute or chronic œdema, and the perichondrium may become exposed and inflamed. The cricoid cartilage is most frequently affected. In rare cases independent perichondritis without ulcerative process is found in tertiary syphilis. Extensive syphilitic ulcers are of especial importance on account of their tendency to form dense, firm scars. Adhesions between the vocal cords may form, usually in front, or circular scars develop, and both conditions may lead to the formation of a sort of diaphragm which obstructs the passage of air, and may even occlude the passage entirely. Lewin has described a case in which the epiglottis became adherent to the aditus. Stenosis may also be the result of ankylosis of the arytenoid joints or may be favored by this condition. Paralysis of the vocal cords dependent more or less directly on syphilis has repeatedly made tracheotomy necessary (posticus paralysis). Gerhardt found this so-called chorditis vocalis inferior hypertrophica 5 times in 26 cases of syphilis of the larynx. He believes, however, that tracheotomy may be avoided by energetic antisyphilitic treatment. A syphilitic history, or symptoms of the disease at the time, are of the utmost importance in the diagnosis, but it must always be remembered that syphilitic individuals may suffer from carcinoma or tuberculosis, or *vice versa*. A sharp red border and a yellow spotted base have been considered characteristic of syphilitic ulcers, although these signs often prove unreliable. The seat of the disease can be made use of as a diagnostic feature only when the lesion is circumscribed. Syphilis frequently begins on the epiglottis, whereas tuberculosis is apt to appear on the posterior wall, and the presence of scars is more in favor of syphilis. Not infrequently energetic treatment with iodides will be necessary to decide the diagnosis.

Syphilis of the trachea is much more uncommon than lues of the larynx (bronchi very uncommon). The larynx is usually involved simultaneously and the lesions are alike. According to Schrötter, gummatous infiltration and secondary ulcers are seen most frequently. Usually larger areas are diffusely infiltrated. Prominent, sharply defined, circumscribed tumors are seen but rarely. The region most often affected is immediately above the bifurcation; next, the beginning, and then the middle portion; but it is uncommon to have the entire trachea involved. The secondary conditions are the same as in any extensive process in the larynx (perichondritis, scar formations). Life is endangered by shutting off the supply of air, not only in the stage of infiltration, but also because of the resulting scars. The danger of ulcers perforating the neighboring regions is also to be remembered (mediastinum, œsophagus, cava, aorta, arteria pulmonaris, and in favorable cases externally). The peritracheal tissue may be involved by gummatous infiltration, thus giving rise to adhesions with neighboring organs and producing pressure on vessels and nerves.

The prognosis is far graver than in simple disease of the larynx itself, but in either case it depends largely upon early recognition of the nature of the disease. Recovery may take place under specific treatment without extensive scar.

Treatment.—It need not be emphasized that early and appropriate antisyphilitic treatment is the main factor in curing syphilis of the larynx and trachea. The sooner this general rule is observed, the fewer the cases that will come under the care of the surgeon. Congestion is interesting from a therapeutic standpoint only, because it may at times be necessary to perform a tracheotomy. Gerhardt believes that the percentage of syphilitics that come to tracheotomy can be expressed in tenths of 1 per cent. The results of tracheotomy done for syphilitic stenosis are brilliant, which is easily understood when the seat of the lesion is taken into consideration. Vierling reports 2 cures out of 14 cases, and 2 cases of improvement lasting for several months, whereas the others died immediately or soon after operation. A patient operated on by P. v. Bruns in whom the infiltration was partially excised still lives seven years after the operation, and another is living after thirty years.

Actinomycosis of the Larynx.—This condition, which has only been known for thirty years, is receiving more consideration by the practitioner, for several observations have been reported in which the larynx was involved.

The larynx is affected as the result of a lesion in the neighborhood (in the cases reported by Illig and Störk there was extensive infiltration in the region of the lower jaw and of the anterior and posterior portions of the neck and of the pharynx; in Maiockhi's case the tongue was involved at the same time); or the larynx alone is diseased. Three cases illustrating this condition have been reported by Mündler in Czerny's clinic. All presented the clinical picture of perichondritis externa of the thyroid cartilage. In a case reported by Poncet the disease began as a perichondritis of the thyroid. In two of Czerny's cases the laryngeal picture as seen in the mirror was normal; in the third case there were a tumor of one arytenoid cartilage and swelling of the aryteno-epiglottidean fold. Störk reports a tumor of the thyroid, whereas Illig found one entire half of the larynx œdematous and swollen. In Czerny's cases there were fibrous bands extending toward the lower jaw, which indicated the track along which the infection travelled. The surgeon therefore is not in a position to assert definitely the possibility of primary actinomycosis of the larynx; for even the laryngoscopic picture is by no means sufficiently characteristic to enable a definite diagnosis. The condition of the external soft parts will lead to a more reliable conclusion; for instance, if there are brawny infiltration and the absence of glandular swelling. An absolute diagnosis can be made only by finding the specific fungi.

Treatment.—The most appropriate treatment, considering the present knowledge of actinomycosis, is a combination of surgical treatment of the masses of granulation and the internal administration of potassium iodide (45 to 90 grains a day). The prognosis with this form of treatment is not very unfavorable. Illig's patient was cured by injections of corrosive sublimate. In Czerny's cases opening of the abscesses with curetting, and in Störk's case this treatment combined with the administration of potassium iodide, led to recovery. Poncet's case died in spite of treatment with potassium iodide. Chronic suppuration of the neck developed, followed by cachexia and acute pleurisy.

Scleroma of the Larynx.—This condition is an accompanying phenomenon of the disease described by Hebra in 1870, and called by him rhinoscleroma. Bornhaupt has described a condition which he terms scleroma respiratorium. It is uncommon to have the larynx alone affected. According to Wolkowitsch, the larynx was affected 19 times and the trachea 5 times in 85 cases. In the larynx the subglottic region is most frequently involved, next the vocal cords themselves, and rarely the aditus. The disease manifests itself generally as a diffuse infiltration, at first soft, and later forming cartilage-like masses that finally become dense contracting scar-tissue without undergoing purulent disintegration, as emphasized by Hebra. Circumscribed disseminated nodes are occasionally observed. These seem to appear in the region of the aditus, and, according to Juffinger, in especially severe types of the disease. When the infiltration occupies the usual region, there will be impairment of the voice and interference with respiration even to suffocation. As long as these symptoms are absent there are the usual signs of catarrh, to which little attention is paid as a rule.

Diagnosis.—The diagnosis is usually based upon the existence of sclerotic changes in the nose and pharynx at the same time. With primary scleroma of the larynx, the slowly developing stenosis and absence of pronounced inflammatory and ulcerative process, and the subglottic swelling in the absence of signs of syphilis or tuberculosis, will be important differential points. All doubt is removed when it is possible to find the bacilli of rhinoscleroma in the secretions or in excised bits of tissue (Frisch, 1882).

Prognosis.—The prognosis is unfavorable, because scleroma is an incurable progressive disease. The course is extremely chronic and may extend over twenty or more years. In rare cases the infiltration may within a few years involve the laryngotracheal tube as far as the bronchi.

Treatment.—Considering the impossibility of a radical cure, the treatment is mainly symptomatic. In extreme cases tracheotomy may be necessary. Billroth in 1884 first attempted to restore the lumen of the organ by opening the larynx and excising the internal soft parts of the larynx. His example has since been repeatedly followed; Pieniázek alone has performed 130 laryngotomies, chiefly for scleroma. He considers that this is the most satisfactory and quickest method of treatment. Post-operated stenoses may be avoided by methodical dilatation. This, however, is necessary, according to Pieniázek, only in exceptional cases, especially when the posterior wall is extensively involved. This author prefers primary suture of the larynx with iodoform gauze packing, whereas Mikulicz allows the wound to remain open and uses a glass canula. When the disease affects the aditus, a combination of laryngotomy and pharyngotomy subhyoidea may be necessary (one operation by Pieniázek). The facts that the patients do not suffer from recurrence for years after the operation, enjoy normal respiration, and at times have satisfactory use of their voice, justify this method of treatment. Bloodless dilatation is wearisome and promises success only when the diseased tissue is comparatively soft. Stenosis of the trachea, especially in the lower portion, is a difficult condition to handle. Pieniázek has achieved temporary results by dilating with catheters of increasing calibre and then removing the growth with a curette under guidance of his tracheal speculum (even the bronchi have been curetted).

Leprosy of the Larynx.—Leprosy of the larynx will be mentioned in this connection solely as a possible cause for tracheotomy. According to Bergengrün, this has to be done in all cases of leprosy sooner or later. The disease always begins in the epiglottis, and may be limited to this region; in other cases the entire larynx may be involved. There may be diffuse and nodular infiltration, deep ulcers, circumscribed nodes of granulation-tissue, and snow-white stellate shining scars.

Diagnosis.—The diagnosis is usually easy, because the condition is always secondary. In doubtful cases anæsthesia of the affected region and the presence of bacilli of leprosy will decide the question.

Prognosis.—Involvement of the larynx in this disease is of importance as far as the prognosis is concerned only because it may shorten the course of the malady by producing death from suffocation. Statistics vary as to the frequency of this result. Hillis states that 38 per cent. of the fatal cases are due to stenosis of the glottis. In the Leprosy Hospital, Riga, 7 per cent. of the patients had tracheotomy performed during five years.

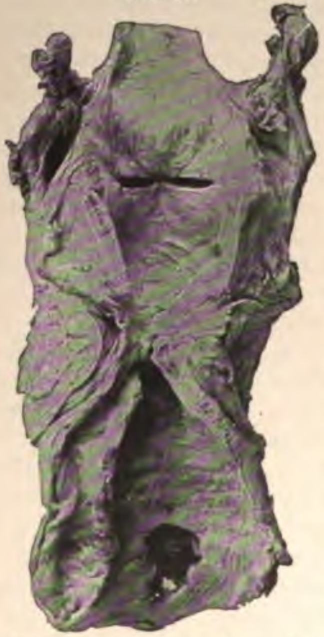
Treatment.—Bergengrün recommends tracheotomy when the dyspnœa is slight, so as to prevent unnecessary suffering, and it should also be done when the stenosis is steadily progressing.

STENOSIS OF THE LARYNX AND TRACHEA.

Stenosis of the Larynx.—More or less complete occlusion of the lumen is of especial importance to the surgeon during the course of various diseases of the larynx. Sometimes stenosis disappears of itself as soon as the disease has run its course. Sometimes it is a secondary development persisting after recovery from the primary disease, or developing during recovery or after this has taken place. Almost all diseases of the larynx may give rise to permanent diminution of the lumen; some exceptionally and others with great regularity. This undesirable combination is most frequently a sequence of some injury; the next most common cause is a tertiary syphilitic lesion; and finally perichondritis from some source or other. In inflammation of the perichondrium acute infections play the most important part—typhoid, variola, scarlet fever. Lüning collected, in 1884, 200 cases of typhoidal stenoses of the larynx. Late stenosis, caused by the diphtheritic process itself, is rare compared with the frequency of this disease of the larynx, although forming a large percentage of the total number of obstructions. Post-diphtheritic stenoses are much more frequently connected with the treatment. They may follow tracheotomy as well as intubation. Diphtheritic scars are found almost exclusively in the lower portion of the larynx.

The anatomical changes that influence the lumen vary considerably. With fractures, the cartilage may become fixed in an abnormal position by the cicatricial tissue. Callous thickening and fibrous adhesions following extensive laceration of the mucous membrane are also factors of importance in this connection. Dislocation inward of one or both vocal cords, due to displacement and fixation of the respective arytenoid cartilages or damage to the muscles and nerves, may result in stenosis or aggravate the same. After incised wounds that heal by secondary intention diaphragm-like scars have not infrequently been observed. Sometimes the upper portion is almost completely shut off by a funnel-shaped scar. The dislocation of broken-off bits of cartilage and displacement inward of the upper skin margin favor the development of stenosis, especially if there are adhesions between the opposed cut margins. This latter condition will, of course, be more frequent when there is a great deal of granulation-tissue. When there is complete separation at the level of the ligamentum conicum, the lumen is especially liable to become obliterated because the liberated cricoid, according to Schüller, is pulled forward by reason of the traction of the vocal cords. Diaphragm-like scars are of importance as secondary conditions following inflammatory processes, especially after syphilis. Opposed regions become adherent, especially the vocal cords, but the false cords or the subglottic granulating surfaces may also be affected. The adhesions usually develop from the

FIG. 67.



Cicatricial obliteration of the larynx after attempted suicide. (Tübingen.)

anterior angle of the thyroid cartilage backward. Secondary progressively increasing scars gradually diminish the size of the remaining lumen. Anatomically they may resemble congenital diaphragms. Infiltration extending over considerable areas, and followed by secondary folds of scar-tissue, may lead to the formation of elongated, cylindrical, stricture-like canals (scleroma and perichondritis of the cricoid and thyroid cartilages). Collapse of the larynx after separation of large sequestra of cartilage has been mentioned in the paragraphs treating of perichondritis. In inflammatory processes, luxation and ankylosis of the arytenoid cartilages are of importance in producing stenosis.

Diagnosis.—Dyspnœa and stridor are the cardinal signs of stenosis of the larynx. The degree to which these symptoms are present may vary in different cases, according to the diameter of the remaining opening. The rapidity with which the stenosis has developed bears some relation to dyspnœa. It is remarkable how the air-supply adapts itself to the gradual diminution in chronic stenosis. The symptoms which accompany marked stenosis have been considered in the paragraphs on Diphtheria. Disturbances of the voice depend largely on lesions affecting the vocal apparatus itself, and when the vocal cords are intact they may be due to the fact that the quantity of air necessary to produce sound is not available.

Prognosis.—As far as the prognosis is concerned, one should differentiate between cases that have been tracheotomized and are therefore not liable to immediate suffocation, and those that have not been operated upon. Although the latter group includes slight degrees of occlusion that as a rule do not endanger life, still an otherwise harmless catarrh may give rise to sudden suffocation.

The chances of restoring normal respiration and phonation depend so greatly upon the etiological and anatomical conditions of the individual case that no general rule can be applied. Although during the last decades brilliant recoveries have been made, the unfortunates who are obliged to wear a tube for life or who voluntarily retain the same for fear of recurrence, are in the majority. This, however, is apparently due to the fact that a large percentage of the patients prefer a permanent fistula to the eventual recovery that follows treatment demanding the greatest amount of patience, intelligence, and will-power. Statistics, therefore, are of little value as far as the prognosis is concerned.

Treatment.—It is self-evident that even chronic stenosis of the larynx may give rise to sudden danger from suffocation and demand immediate tracheotomy. In these cases the increase of symptoms is gradual, but it should be emphasized that the interest of the patients demands that the surgeon never allow the period of disturbed compensation to be reached, especially since moderate degrees of stenosis may undergo sudden vicious change at any moment.

The therapeutic measures directed to removal of the stricture may be classified as follows: 1. Intralaryngeal dilatation without preliminary tracheotomy; 2. Dilatation with preliminary tracheotomy, the opening of which is made use of for this purpose; 3. Laryngotomy; 4. Resection of the larynx.

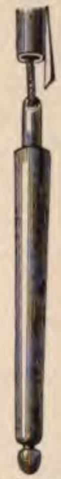
Dilatation may be aided by endolaryngeal section of scars with a laryngeal knife or with the cautery. This has been done repeatedly with success where the membrane has been thin (laryngotomy interna). Excision of the entire membrane (endolaryngeal) has also been done successfully. In stenosis due to syphilis the surgeon should combine with local treatment the administration of specific drugs. Even extralaryngeal interference must, as a rule, be followed by dilatation from within.

Hard-rubber tubes are used as dilators. These are 26 cm. long, and have at their tip a central and two lateral openings. The anterior portion is prismatic with blunt corners corresponding to the triangle of the glottis. This shape allows of considerable dilatation in the sagittal plane without too marked pressure upon the vocal cords, which cannot be avoided with cylindrical bougies. According to Schrötter, these dilators should always be introduced with the aid of a mirror after the patient has practised for a time with English catheters. The stricture should be dilated with these until it is possible to introduce the hard-rubber tubes. Schrötter considers that cocaine as a rule is unnecessary. At first the tubes are left in place for a short time only, but later for at least one-half hour. The same author recommends that this treatment should be applied at least twice a day after the patient has become thoroughly accustomed. The limit to which one may go in this direction will depend somewhat upon the degree of local reaction and largely upon the character of the patient. If the normal lumen has been reached, treatment must be continued for several months. Intelligent patients may in the meantime learn to pass a bougie. Rough handling is to be avoided.

There is always some congestion and slight swelling at first, and œdema, pressure-ulcers, submucous inflammation, and even perichondritis, with considerable rise in temperature, have been observed to follow dilatation. Such unfavorable occurrences may necessitate tracheotomy at any time. Jacobson had one patient succumb to sudden œdema of the glottis after three weeks of treatment. Of 47 cases collected by Heryng, the respiration became normal in 27, in 12 the voice was restored, and death occurred in 5. A large number of cases have since been reported. The author does not consider it justifiable to judge of the value of this method of treatment from statistics, because of the extreme variation of conditions in individual cases.

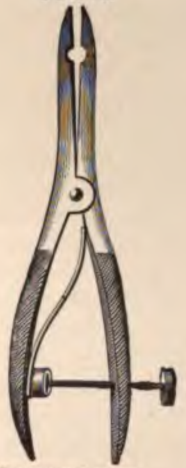
During the last decade O'Dwyer's intubation has to a certain degree supplanted Schrötter's treatment of chronic stenosis by dilatation. Special tubes are used for this purpose. The chief advantage is that the tubes may be left in place for some time, which, is impossible with Schrötter's tubes, which project from the mouth, even though they may not cause excessive salivation, as observed in some cases. Intubation has been frequently performed after tracheotomy, for the purpose of preventing subsequent stenoses of the larynx and trachea. Killian has improved this method, and allows the tube to remain in place for two to three weeks. The opening in the trachea, which is kept patent during the treatment, is made use of for holding the tube in place by means of a thread, and coughing up of the tube, so disastrous at times, is thus prevented.

FIG. 68.



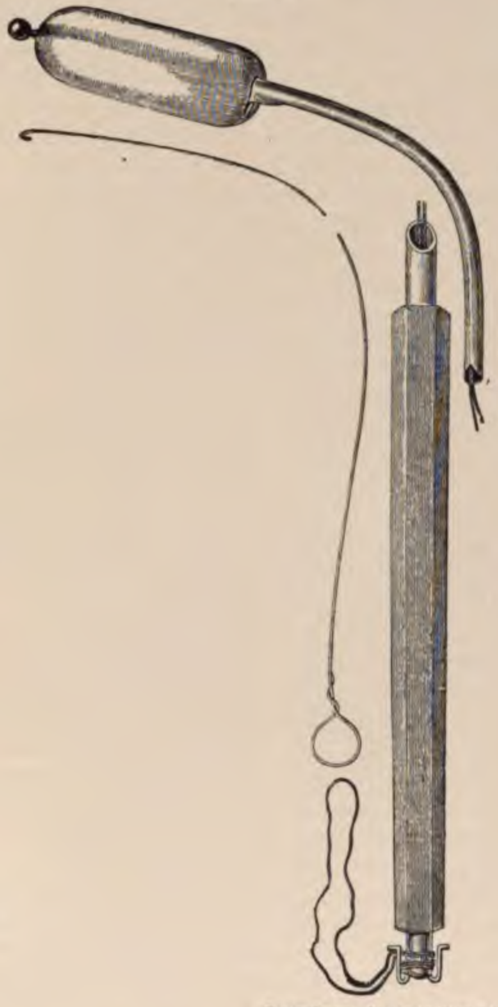
Schrötter plug.

FIG. 70.



Pressure-forceps.

FIG. 69.



Introducer for Schrötter plug.

Instead of metal tubes, hard-rubber tubes have been recommended because there is less danger of pressure-ulcers. The reader is referred to the original article of Killian for the detailed description of this form of treatment. An existing tracheotomy-wound may be made use of for the purpose of dilating. P. v. Bruns passed a thin, filiform bougie upward into the mouth, which served as a guide for the conical hollow bougie. He has done this repeatedly with success.

Schrötter's tin plug method is generally known. (This was made use of in a similar way by Trendelenburg for the purpose of dilating a stricture of the trachea after previously opening the same). Schrötter's plugs (Fig. 68), like the hard-rubber tube, are triangular on section with rounded-off corners. They are 4 cm. long and are in twenty-four sizes. The anteroposterior diameter varies from 8 to 20 mm. and the transverse diameter from 6 to 16 mm. They are introduced by means of a catheter-like tube (Fig. 69), into which the peg in the upper portion of the bulb is drawn and held in place by means of a strong thread. The thread is left in place for the purpose of subsequent extraction. For the purpose of preventing the bulb from slipping out of the stenosis, which is usually funnel shape upward, a small round knob has been attached to the bottom of the bulb, which extends into the canula through a small opening and is held in place by a small pair of pressure-forceps. (Fig. 70.) Störk makes use of a small hook on the internal canula which fits into a hole on the bulb, whereas Heryng uses a slit in the inner tube which fits around the neck of the knob. Dilators with several flanges, which were introduced through the tracheal wound and distended the stricture by means of a screw, have been abandoned by their inventor because the use of the screw power caused violent pain which radiated to the temples.

Corradi has recommended the use of laminaria tents, which were drawn into the stricture by means of a thread protruding from the mouth. A second thread was attached below to the tube. Newmann used tupelo dilators in a similar way.

If dilatation has progressed sufficiently to permit free respiration for several days with a closed canula, the latter may be omitted. The lumen should be kept open by the use of bougies and hard-rubber tubes. These should be passed beyond the seat of the tracheotomy-wound, as emphasized by Schrötter, so as to prevent the development of a stricture at this point. Premature removal of the canula not infrequently necessitates a second tracheotomy. Of 36 cases reported by Heryng the tube could be removed in 8; in 10 improvement followed, although the canula was still made use of; in 4 cases repeated tracheotomy became necessary, and in 14 there was no or very slight improvement.

Laryngotomy has been done for opening up the stenosed larynx for introducing dilating apparatus (T-canulas, etc.), and it has served as a preliminary step for operative or galvanocaustic excision of constricting tissues. Surgeons have become familiar with membranous diaphragms, diffuse prominent scars, hypertrophied masses of callus, and chronic inflammatory folds of the mucous membrane. Heine and P. v. Bruns performed subperichondral resection of portions of the thyroid and cricoid cartilages when the thickening of the laryngeal wall was so great as to make the success of simple laryngotomy doubtful. The selection of the method to be used will depend, first of all, upon the anatomical changes in the individual case. It has been emphasized that the individuality of the patient is of great importance. His social standing or other more or less incidental conditions may decide in favor of one or the other method. It should be remembered that the dilatation method frequently takes months, or even a year or longer. As far as the stricture itself is concerned, it is self-evident that endolaryngeal dilatation in general can be applied only to the slighter forms for the reason that patients with severe chronic stenosis usually come to a specialist after having had tracheotomy performed. Even when this is not the case, the method is to be restricted to the more moderate degrees of stenosis which lead one to hope for rapid improvement. For instance, delicate membranes and pliable hyperplasia may be treated in this way.

The fatal cases reported show that too great reliance may be placed on the value of simple catheter treatment. The surgeon should refrain from such treatment if the patient cannot stay in the hospital, where tracheotomy can be performed at any moment. In the later stages, when an appreciable result has been obtained, and it has been demonstrated that the larynx has become tolerant to interference, it may be justifiable to treat in an ambulatory way. Dilatation combined with tracheotomy gives much more favorable results. The short bulbs (or intubation-tubes) may be left in place much longer, or remain permanently *in situ*. There is comparatively little danger of suffocation. Killian, to be sure, lost one child from suffocation with intubation treatment. It is undeniable that it is possible to remove very extensive strictures provided the physician is thoroughly familiar with the technic of using the tin bulbs. Whether it is advisable to apply this method in any case in which bulbs might be used, is another question. With tight callous strictures, especially with cylindrical or irregular canals, varying in extent, it may be possible to obtain a practically normal lumen after weeks or months of careful work, provided the patient does not lose patience. These scars always have a tendency to contract.

Laryngotomy has the advantage of giving a normal lumen immediately by destroying constricting scar-tissue. Mouth-breathing is restored with aid of a proper laryngeal tube, and the after-treatment consists in maintaining what has so quickly been gained. There is no doubt that a dense scar may be overcome by energetic dilatation. Some idea of the tolerance of the larynx and of the patient may be obtained by reading Thost. The bulb was suddenly drawn well down into the trachea by considerable force and the tube with which the bulb was introduced repeatedly bent double. The dangers of laryngotomy as an open operation are nowadays offset by the possible after-effects of treatment by dilatation. The dangers associated with tracheotomy and with tracheal tubes are alike for both methods in the types of stenosis to be considered here. The results have undoubtedly improved with the increasing number of laryngotomies, as is shown by the experience of Mikulicz, Pieniázek, Lemke, and others. It should, however, not be overlooked, that laryngotomy does not always free the patient from his laryngeal tube. The chances are especially unfavorable in cases of fixation of the arytenoid cartilage. Excision of the corresponding vocal cord has not given very favorable results, and dilatation in these cases is fruitless. It is not possible that dilatation alone could have been of value in cases in which laryngotomy was without result. Failure is often the result of insufficient or inadequate after-treatment. Any patient who does not carry out directions after laryngotomy will certainly not follow up the irksome treatment of dilatation. It is a well-established fact that extralaryngeal interference has repeatedly been followed by recovery when the dilatation method has failed. The patient, himself, will have to determine whether an artificial larynx is satisfactory or not.

As far as the indications for laryngotomy are concerned, the author defends the position taken by Schüller and P. v. Bruns and most surgeons and many laryngologists. This operation is indicated primarily in very tight and firm strictures, especially if they are of considerable length or have irregular walls. In cases in which it is not possible to decide immediately, laryngotomy will be indicated after attempts at dilatation have proved unsuccessful.

Stenosis of the Trachea.—The extramural causes that diminish the lumen of the air-passages are far more common in stenosis of the trachea than when the larynx is involved.

Etiology.—Most stenoses of the trachea are produced by external pressure, with enlargement of the thyroid gland first on the list. Those cases in which disease of the neighboring structures extends to the tracheal wall or infiltrates this, are on the border-line between extratracheal and intratracheal stenosis. To this group belong malignant growths and the rupture of broken-down bronchial glands into the air-passages. Intratracheal stenosis results from the same processes that were mentioned in connection with the larynx. A construction is more uncommon in this region except the variety secondary to tracheotomy. Of the inflammatory affections that in themselves may give rise to stenosis of the trachea, syphilis is the most important. This may produce bands that project into the lumen of the tube or it may give rise to a diffuse welt-like thickening of the wall. Postdiphtheritic stenosis, which should be mentioned first, always bears more or less relation to tracheotomy, and will therefore be considered later in connection with the secondary results of this operation.

The severest type of traumatic stricture is that due to transverse separation. Rupture of the tube (Noll, Küster) and incised wounds (v. Eiselsberg) are of about equal importance. Half-moon or circular scars, and even cases of complete obliteration of the upper portion of the trachea, have been observed. Complete healing over of the upper section of the trachea is favored by marked retraction of the lower portion in cases of transverse separation. Stenosis due to scar-tissue has been repeatedly observed after gunshot-wounds.

Symptoms.—The general symptoms of stenosis of the trachea do not differ materially from those of stenosis of the larynx. If stridor is marked, it may at times be possible to determine the seat with a fair amount of accuracy by auscultation and palpation along the course of the trachea. The characteristic signs emphasized by Gerhardt, such as diminished inspiratory excursion downward of the larynx, flexed position of the head in stenosis of the trachea, and marked descent of the larynx and extension of the head in stenosis of the larynx, are considered by Schrötter and others to be inconstant signs and of uncertain differential diagnostic value.

Diagnosis.—The diagnosis may frequently be made from the external conditions, the general symptoms, and the history of the case. Not infrequently laryngoscopic examination will give information regarding the finer anatomical details of the stricture. In other cases this method of examination will give at least an approximate idea as to the seat. Special difficulties and disagreeable surprises may arise because of several strictures, a condition that has repeatedly been observed. According to Schrötter, there is ground for suspicion that a second deep-seated stenosis is present if the calibre of the constriction first detected does not entirely explain the dyspnœa.

Prognosis.—The prognosis of stenosis of the trachea varies in different cases, according to the nature of the fundamental lesion, the lumen, and the seat of the stricture. The deeper down the obstruction, the greater the danger to life, other things being equal. If the surgeon is able to perform tracheotomy below the constriction, the conditions are, of course, much more favorable than in cases in which it is necessary to overcome the obstruction by means of a tube or where the stenosis cannot be reached. It is evident that attempts at a radical cure in intratracheal stenosis will meet with greater difficulties the farther the seat of operation is from the larynx.

Treatment.—The treatment of stenosis of the larynx varies according to the cause. In stenosis due to compression the efforts of the surgeon should first be directed to relieving the pressure. If successful, the symptoms of obstruction usually subside immediately. In all varieties of stenosis of the air-passages tracheotomy may have to be considered with reference to avoiding the danger of suffocation before undertaking any radical step. The author agrees absolutely with Grossmann, who recommends tracheotomy even when the seat of obstruction is quite low down. In individual cases at least it gives the possibility of reaching with instruments an obstruction which otherwise would be inaccessible.

The same methods are to be considered in the radical treatment as have been described in connection with the larynx. It will, of course, be necessary to modify instruments corresponding to the deeper regions to be reached. Schrötter, and later Landgraf and Seifert, have successfully dilated constricted bronchi. Tracheotomy, just as laryngotomy, may take the place of external section of a stricture. Constricting scars may be dilated or cut through the tracheotomy-wound, as demonstrated by Trendelenburg. Extensive circular scar stenoses or complete occlusion form an indication, according to the experience of Küster and v. Eiselsberg, for circular resection with subsequent suture of the trachea. It is advisable to make a fresh longitudinal incision for the tracheal tube which is to be worn during the first days. König's case proves that it may be possible to unite the ends even when the lesion is extensive (repeated operations if necessary). The plastic operations necessary for the removal of valve-like stenosis will be considered in connection with fistulæ.

FISTULÆ OF THE LARYNX AND TRACHEA.

These are the result of injury or of ulcerative destruction of the wall. The author distinguishes with Schüller an ulcerative and a cicatricial variety. The former have been mentioned in the paragraphs on perichondritis in connection with rupture of an external perichondritic abscess. The opening of the fistulæ is usually situated in the side of the neck at about the level of the lower margin of the thyroid cartilage, or even lower. Diphtheritic processes, as has been seen, play an important part in the etiology of these fistulæ, for when the local lesion extends to the tracheotomy-wound extensive destruction of the laryngotracheal tube sometimes results. The sinus may also result from disintegration of a carcinoma. All of these ulcerative fistulæ are of little significance compared with the severe diseases in the course of which they occur. Cicatricial fistulæ alone are of especial importance.

Cicatricial fistulæ are the result of the above-mentioned ulcerative processes (except carcinoma), or more frequently they are found to be secondary to injuries. The skin and the mucous membrane become united just as in the case of the lips. This frequently occurs after necrosis of the cartilage has resulted in a defect of the wall. Fistulæ are comparatively often the result of incised wounds made with suicidal intent. The size of the wound, its nature, multiple incisions into the cartilage, complete transverse separation, the course, and the treatment influence the character of the resulting scar materially. Fistulæ after stab- and gunshot-wounds are comparatively uncommon. Operative opening of the air-passages is rarely followed by fistulæ, aside from those cases in which it is intended to leave a permanent opening or in which stenosis counterindicates removal of the tube.

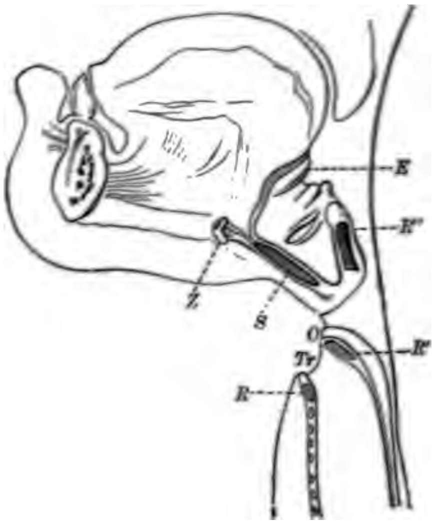
There are two kinds of fistulæ distinguished according to their topographical relation to the air-tube. There are more or less extensive lateral openings in the wall or the opening corresponds to the entire lumen of the tube, which is, however, as a rule, somewhat diminished concentrically. The latter type of fistula, as is self-evident, presupposes complete transverse section of the tube, and is always complicated by separate cicatrization of the upper section. Even in fistulæ of the wall it is common to have stenosis as a complicating element. These conditions are not infrequently intimately associated as far as their cause is concerned, and influence each other mutually; so much so that in many cases it is not possible to consider the conditions separately.

In cicatricial fistulæ the external skin is usually drawn in. There is either a cutaneous funnel, in the bottom of which the opening into the trachea may be seen; or there is a small fistula with a small opening lined with epidermis. The neighboring skin is thrown into small radiating folds around this opening. After extensive loss of tissue the portion of the tracheal wall in the vicinity of the fistula, formed by unsupported scar-tissue, is sucked in during inspiration (valve stenosis). Even a simple cicatricial funnel may be seen to close with inspiration if there is obstruction to breathing above, so that patients, as a rule, cannot abstain from the use of a tube for even a short time. Permanent removal of the tube is counterindicated on account of the tendency of the opening to close by cicatricial contraction. The importance of these fistulæ varies in individual cases. Small fistulæ are simply annoying because they allow air and mucus to escape on coughing; larger ones impair the voice, so that it is necessary to close the opening with the finger before the patient can speak. The author has observed a case of this sort, and one has been described by Schimmelbusch in which the opening was closed by flexing the chin. If marked stenosis is present, the fistula is essential to life. On the other hand, the dangers resulting from continual wetting of a tracheal tube are factors to be considered.

A fistula of the trachea may be complicated with one of the œsophagus after injury. Fistulæ situated above the thyroid cartilage will not be considered, inasmuch as they belong to the pharynx. In complete transverse section of the larynx or of the upper portion of the trachea the wall of the gullet, if injured at the same time, may protrude between the separated ends of the air-passage and become united with the external scar. Fig. 71 represents a case of this sort, observed by Hüter. The fistula of the œsophagus should, of course, be closed first. Laryngo-œsophageal and tracheo-œsophageal fistulæ are to be distinguished from these because there is a communicating opening in the partition between the two tubes. It has not been proved whether this type of fistula may be produced by external injury, although it can be conceived of theoretically (in gunshot- and stab-wounds between these tubes). The rapid healing of the wound in the œsophagus guards against this occurrence, as shown by experience. On the other hand, there is quite a series of observations bearing on ulcerative perforation of the dividing wall. The most common cause is some foreign body in the air-passages or œsophagus, or a neoplasm (carcinoma of the œsophagus). The nature of the primary process could not be determined in a series of fistulæ of this sort found on autopsy. The practical importance of the condition is in relation to the entrance of food into the tracheal tube, with the resulting danger of aspiration pneumonia, which has not infrequently been the cause of death in these cases.

Diagnosis.—The diagnosis is difficult because the coughing produced by the food in the trachea may easily be considered as the result of faulty swallowing. If, however, the possibility of an abnormal communication is thought of, Gerhardt's method gives an accurate way of making a diagnosis. This method is based upon the fact that a patient with a tracheo-œsophageal fistula is able to blow continually through a stomach-tube in the œsophagus as long as the end is above the fistula, whereas a normal individual can only press out the small amount of air contained in the œsophagus. This test is best performed by placing the external end of the tube under water.

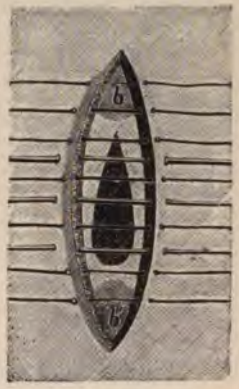
FIG. 71.



O, fistula of the œsophagus; *Tr*, fistula of the trachea; *R*, *R'*, *R''*, ring-cartilage; *S*, thyroid cartilage; *E*, epiglottis; *Z*, hyoid bone. (Schüller.)

Treatment.—It is permissible to close the fistula only when stenosis is not marked, and removal of this constriction is not infrequently the most difficult portion of the therapeutic task. Operations performed for the purpose of closing a fistula are included in the term bronchoplastic. (Dieffenbach.) It is impracticable to enumerate all the different methods and modifications that have been devised for this purpose, but when the fistula is very small some caustic, of which the cautery is the most convenient and the most certain in action, has at times given good results. Sometimes a purse-string suture is used at the same time. Small fistulæ may be closed in a simpler and more accurate way by excising all the scar-tissue and the tracheal opening. The elliptical defect in the trachea is closed with catgut and the skin sewed over this. A drain is left in to avoid emphysema. Simple freshening of the sinus and a deep suture will often give the same result, but this method of treatment is limited by the size of the wound. The "plastique par doublure" principle has been applied in various ways in cases of large fistulæ. Usually Balassa's method has been followed and a pedunculated skin-flap turned into the tracheal wound, the edges of which have been freshened. The epidermis is placed inward. The author has been unable to ascertain whether the method suggested by Hüter has ever been made use of practically. The edges of the fistula are turned in and sewed together and then covered with two skin-flaps taken one from each side. Jacobson closed an elongated fistula of the trachea in the manner depicted in Fig. 72, showing the method of freshening the edges and placing the sutures. The shaded region *b* and *b′* should also be freshened. The incisions must not involve the subcutaneous tissue because emphysema may develop.

FIG. 72.



Bronchoplastic. (Jacobson.)

If the anterior wall of the trachea has been destroyed to a considerable extent or replaced by soft scar-tissue, a wall must be made that is capable of resisting the atmospheric pressure during inspiration. Schimmelbusch devised a method which provides for the cure of cases of this sort. He frees a skin-and-periosteum flap from the sternum, turns it upward, and sews it to the margins of the tracheal wound. Photiades and Lardy have made use of a pedunculated flap from the clavicle with success. In the severer cases a number of operations are necessary to obtain a cure. When several centimetres of the laryngotracheal tube are destroyed and the circumference is extensively involved, a bone plastic is the only means of repairing the damage. When small defects in the cricoid cartilage or in the trachea immediately adjoining are to be closed, the method of Fritz-König is best, for this corresponds more closely to the physiological processes of repair. He uses the cartilage of the larynx. The flap is taken from the thyroid cartilage by removing the external half of the cartilage with the overlying soft parts. A flap taken from the skin of the fistulous tract is placed beneath this with the epidermis inward, and sewed with catgut. v. Mangoldt has recently used the cartilage of ribs as a means of replacing the defect. Grosse has successfully employed silver wire netting for the purpose of giving sufficient support to the softened anterior wall of the trachea.

A fistula between the œsophagus and trachea at the level of the sixth cervical vertebra was successfully treated by Brenner (œsophagotomy, freshening of the edges of the fistula, separation, and suture of the wall of the œsophagus).

NEUROSES OF THE LARYNX.

It has been mentioned that in the various processes in the larynx giving rise to stenoses the obstruction to respiration may become so great as the result of immobilization of the vocal cords that the supply of air becomes insufficient. Unilateral paralysis, if associated with other conditions, may in this way be an indication for tracheotomy. Bilateral paralysis by itself is capable of markedly influencing respiration. It is not so much a total paralysis of the recurrent nerves as a bilateral posticus paralysis which makes tracheotomy necessary, and the frequency of this condition renders it of practical importance. Under the name of Semon Rosenbach's law, it is well known to laryngologists that paralysis of the abductors of the glottis may take place much more easily and earlier from central as well as from peripheral causes than that of the adductors. Posticus paralysis therefore is considered a preliminary stage of total recurrent paralysis, and may exist as such for years. The bilateral paralysis which concerns the surgeon is of central origin in the vast majority of cases. Diseases which give rise to bulbar symptoms may also produce posticus paralysis. Tabes is first on the list. It will be readily understood that peripheral influences, such as pressure from thyroid cysts, aneurisms, carcinoma of the œsophagus, etc., is a far less frequent source, especially if it be taken into consideration that bilateral paralysis would necessitate a more or less uniform mechanical influence on both recurrent nerves, which are seated at some distance from each other. The mechanism of stenosis in posticus paralysis is simple. The vocal cords remain in the median line, so that the glottis is reduced to a narrow slit. Dyspnœa is exclusively inspiratory. It is increased by approximation of the cords during forced inspiration, whereas during expiration the cords are separated. Discussion has arisen among laryngologists regarding the pathology of this median position. The author cannot here enter into the subject more in detail. Corresponding to the very gradual development of paralysis and the paralytic contraction of the abductors, the resulting stenosis has the peculiarity common to all slowly developing obstructions to respiration, viz., that it may become marked without producing subjective signs of dyspnœa, and is also associated with the danger that any adventitious swelling may suddenly cause death.

An accurate diagnosis is possible only with the aid of a mirror, and the reader is referred in this connection to special works on laryngology.

Treatment.—According to Semon's direction, tracheotomy should be performed as a prophylactic measure in any case of bilateral abductor paralysis when it is not possible by other means to produce an actual widening of the glottis. The author agrees with him in condemning permanent intubation, thyreotomy, and excision of the vocal cords. The latter method is not only heroic, but also of uncertain success, and destroys the voice. In bilateral complete paralysis of the recurrent nerves frequent entrance of material into the trachea may necessitate tracheotomy. Spasm of the larynx in rhachitic children should be mentioned, because an attack may at times cause death by suffocation. Pott observed 3 cases of death in children during an attack, and was able to save a fourth by intubation. Kalmus reports several cases of death from suffocation among the 425 cases observed by him in Soltmann's clinic. When there is danger of asphyxia, Monti recommends the use of a catheter after Weinlechner's method and inflation with air if necessary. He considers that tracheotomy is not essential in these cases.

NEW GROWTHS OF THE LARYNX AND TRACHEA.

The vast majority of new growths in the interior of the larynx and trachea belong to the field of laryngoscopic surgery, which has been most successful in this direction. This applies to the majority of all benign new formations, but malignant tumors without exception should be referred to the surgeon.

Tumors of the larynx and trachea will be considered separately.

New Growths of the Larynx.

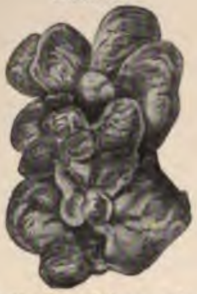
Tumors of the larynx are of frequent ocurrence, and when seated in the most common position, on the vocal cords, they give rise to disturbances of the voice even when very small. F. Semon's collection of cases up to 1888 includes 12,297 tumors of the larynx, 10,745 of which were benign and 1550 malignant; 88 per cent. of tumors of the larynx are therefore benign and 12 per cent. of the total number malignant.

M. Schmidt, during a period of thirteen years, found 2088 new growths in the upper air-passages in a total number of 42,635 patients treated; 748 of these were in the larynx, and 104—*i. e.*, 13 per cent. —were malignant. In the Berliner Universität Polyklinik for diseases of the nose and throat, 189 tumors of the larynx were observed in 27,500 patients during nine years. This did not include singers' nodes. Ten per cent.—*i. e.*, 20—of the tumors were malignant, and men were three times as often affected as women. (Rosenberg.)

Benign Tumors of the Larynx.—Benign tumors of the larynx are almost always fibroma or papilloma. According to the author's experience, fibromata are most common. Of 300 cases observed by him, 55 per cent. were fibromata and 35 per cent. papillomata. The statistics bearing on the frequency of fibroma and papilloma vary so greatly that they can only be explained by differences in opinion. Mackenzie found 67 per cent. of 100 cases, and Fauvel 68 per cent. of 300 cases, to be papillomata; whereas Tobold found 29 per cent. of 209 cases, Schrötter 18 per cent. of 391 cases, and M. Schmidt only 11 per cent. of 566 cases. In the statistics collected by F. Semon, 4190—*i. e.*, 39 per cent.—of 10,747 benign tumors were papillomata. The proportion of papillomata to benign tumors of the larynx in general is therefore about 1 to 2½.

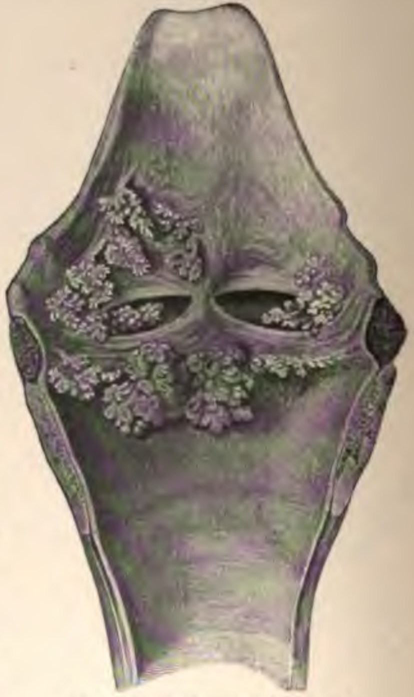
The fibromata which develop in the submucous tissue and are covered with mucous membrane appear at first as small nodes with a broad base, and ordinarily do not become larger than a pea, rarely as large as a cherry. These tumors maintain their broad base while increasing in size, or may develop a short stem-like peduncle. The surface is usually smooth, but may be uneven or nodular. The color is pale or light or dark red, according to the amount of blood contained. They are of dense consistence, although soft fibromata occur which consist of succulent tissue. Fig. 73 represents an enormous soft fibroma of the left vocal cord, which was removed in one piece by means of a wire snare from a man fifty years of age. Fibromata are usually seated on the vocal cords, and as a rule near the commissure. They are not common in any other place in the larynx, and are extremely rare in the posterior wall of the larynx near the plica interarytenoidea. Of 346 fibromata collected, 315—*i. e.*, 91 per cent.—were situated on the vocal cords, 150 on the right and 139 on the left cord; 26 were in the anterior commissure and 3 in the plica interarytenoidea. (Rethi, Gevaert, and P. v. Bruns.) Finally it is characteristic of fibromata that they occur as a rule in adults, especially in men, usually isolated, and show no tendency to recur after removal.

FIG. 73.



Soft fibroma of the vocal cord.

FIG. 74.



Multiple papillomata of larynx.

Papillomata are characterized by their teat-like or wart-like appearance, very much like pointed condylomata of the skin. Sometimes they are elongated like a cock's comb, consisting of an aggregation of tabs and warts developing from a common base. Sometimes the growth is circumscribed, resembling a raspberry or mulberry. Again, they appear in bunches like grapes or as cauliflower-like masses consisting of small groups crowded together. (Fig. 74.) The color of a papilloma is reddish, and when the overlying epithelium is thickened it may be grayish red. When the epithelium has become horny, it may be the color of white chalk (pachydermia verrucosa). The growth may be soft or hard, or even pliable.

Papillomata may be single or multiple. Sometimes they are exceedingly numerous, forming a diffuse papillomatous degeneration of the mucous membrane of the larynx, which may be covered for a large extent or almost completely by cauliflower-like growths. The seat of election is the vocal cords, which are alone involved in more than half of the cases. Even in the other varieties of multiple papillomata the cords are most frequently affected, and sometimes the false cords, the ventricles, or the epiglottis. The posterior wall of the larynx is least affected, and it is especially uncommon to have the plica interarytenoidea involved.

It is furthermore important to remember that papillomata appear in the earlier years of life, and become less frequent with increasing age, so that in middle life and later a growth of this sort is suggestive of carcinoma. Papillomata of the larynx have several times been observed to be congenital. The author has observed about 24 cases in which the infants were hoarse at the time of birth or in which voice was absent. It is much more common to have them develop during the first years of life. Papillomata found in the first five years comprise about one-fifth of the total number of cases. Congenital cases are apt to be of the multiple and diffuse cauliflower-like variety, characterized by rapid growth, and speedily recur after removal.

Other benign tumors of the larynx except fibroma are uncommon. Cystic tumors should be mentioned, inasmuch as they comprise about 4 per cent. of the total number. (Jurasz.) These are hemispherical sharply defined growths with a broad base and more or less transparent, varying from the size of the head of a pin to that of a cherry. They are in all probability retention-cysts. They are most common on the anterior surface of the epiglottis and at the corners of the vocal cords. It is uncommon to find the aryteno-epiglottidean folds or the ventricles of the larynx affected. In 2 cases the author observed cysts of the vocal cords disappear spontaneously.

Myxomata, which are considered by some observers to be quite common in the larynx, are extremely rare. In the majority of the cases the diagnosis was not made microscopically, so that in all probability the cases were not true myxoma, but altered fibroma.

Angiomata are also uncommon. They are most frequently found on the vocal cords and occasionally on the false cords. Simple angiomata appear as flat elevations consisting of fine vessels. Cavernous angiomata, which are more common, form dark-red raspberry- or blackberry-like growths with a broad base. It is extremely unusual to find tumor-like varicosities as bluish nodes. (Chiari.)

Lipoma and adenoma have been observed in the larynx in only a few cases. This also applies to enchondroma, 14 instances of which have been collected by the author. Six of these were of the body of the cricoid and 2 of the ring; 4 were on the inner surface of the thyroid cartilage, and 1 each on the arytenoid cartilage and epiglottis. They all consisted of hyaline cartilage. In one case the enchondroma was of the cricoid cartilage with a broad base toward the posterior and right lateral wall of the larynx below the glottis and filled the laryngeal cavity about one-half. By splitting the uppermost rings of the trachea and the cricoid cartilage and cricothyroid ligament it was possible to remove this tumor and preserve the cricoid. Recovery followed without recurrence.

Tumors of the thyroid cartilage in the interior of the larynx and trachea are more properly grouped with new growths of the trachea, and will therefore be considered in the following paragraphs on growths in this region.

Symptoms.—The symptoms produced by benign new growths depend largely upon their seat and size. In exceptional cases small tumors of the epiglottis and false cords or of the aryepiglottic folds may give rise to no signs whatsoever. The vast majority of tumors are seated on the vocal cords and near the anterior commissure, according to the author's figures, 76 per cent. of 1100 cases. For this reason even very small tumors betray themselves by disturbances of the voice. In the smallest, hardly recognizable singers' nodes there may be only a slight alteration of the voice, but with increase in size progressive hoarseness develops which may increase until there is complete loss of voice as soon as it becomes impossible to close the glottis. Disturbance of respiration is unusual and corresponds with the diminution in the size of the laryngeal lumen. For this reason very small tumors may in children give rise to grave symptoms of stenosis on account of the limited space. The same applies to adults when the cleft in the glottis is diminished, whereas tumors that are not situated in the immediate vicinity of the glottis do not give rise to dyspnoea unless extensive. With pedunculated tumors that move with the current of air and get between the vocal cords the voice may be present at one moment and absent at another, and sudden attacks of suffocation may occur, while in the interval breathing is not interfered with, or at least only very slightly. Sometimes growths of this sort produce a distinct valve-like noise.

Diagnosis.—An accurate diagnosis can be made only by means of laryngoscopic examination, which not only gives information regarding the presence of a tumor of the larynx, but also indicates its seat, the point of origin, its circumference, and its nature. An experienced laryngologist is able in the majority of cases to determine the kind of growth with considerable accuracy from the picture in the mirror. In doubtful cases a number of conditions must be taken into consideration in the diagnosis; for instance, the age of the patient, the rapidity of growth, the presence of glands, and signs of syphilis or tuberculosis elsewhere. Microscopical examination of a portion of a tumor removed will indicate the nature of the growth. In children, in whom laryngoscopic examination is not always successful, the author has repeatedly used Kirstein's spatula with success.

Prognosis.—In benign tumors, generally speaking, the prognosis is favorable. The growth can usually be removed without danger to life and the function of the larynx is completely restored. There are, of course, exceptions where the seat is unfavorable and the broad base of the tumor makes radical removal difficult. After removal of growths on the vocal cords, scars or thickened spots may remain, which are likely to impair the voice or perhaps only the singing voice.

After removal of the tumor a cure is usually permanent because the majority of these growths show no tendency to recur. Papillomata are an exception to this rule, however, because they recur repeatedly. The tendency to recur is least when the growth is single and is greatest in multiple papillomata, especially in the diffuse type, which often recur after repeated removal. Sometimes the suspicion arises that they have become malignant, and that operative interference still further increases the tendency to reappear. However, the valuable statistics of F. Semon have definitely determined that malignant degeneration of a benign tumor of the larynx, even after an intralaryngeal operation, is an extremely rare occurrence, so that the prognosis is in no way influenced. Semon's statistics include 10,747 benign tumors of the larynx, 4190 of which were papillomata. Of these, 45—*i. e.*, 1 in 238—underwent malignant degeneration; 12 spontaneously—*i. e.*, 1 in 211; and 33—*i. e.*, 1 in 249—after intralaryngeal operations. Although these figures in themselves indicate that malignant degeneration of benign tumors of the larynx is extremely rare and is not influenced by operative interference, Semon investigated further with care, and found that of 8216 cases operated upon, there were only 5—*i. e.*, 1 in 1645—in which malignant degeneration was beyond doubt, and 7 in which it was probable—*i. e.*, 1 in 1175.

The tendency of papillomata to recur diminishes from year to year, provided they occur in the early years of life. After repeated operations they reappear in fewer numbers and after longer intervals, and finally cease to grow. The author has, however, observed several cases in which recurrence took place after ten, fifteen, and even twenty-five years, although in a progressively diminishing manner.

As regards the prognosis of benign tumors in children, it should be mentioned that it is more unfavorable than in adults. The growths are almost always papillomata, which are not infrequently multiple and often diffuse; they give rise to severe stenosis in the youthful larynx and may cause suffocation. It should be mentioned that operative interference is especially difficult, and that a radical removal is not often achieved. Recurrences are frequent and after repeated clearing of the larynx the functional integrity of the organ may suffer permanently, not only as regards the voice, but also with reference to respiration.

The result was as follows in 127 children with papillomata of the larynx: Of 48 cases not operated, 32 died (28 from suffocation); 3 recovered spontaneously. Of 26 with tracheotomy, 7 died as the result of operation; of 21 treated by laryngotomy, 8 were permanently cured; of 40 treated by laryngoscopic methods, 13 recovered permanently.

Treatment.—Surgeons and laryngologists have not reached a mutual agreement regarding treatment of benign tumors of the larynx. Rose calls laryngotomy the radical operation for laryngeal polyps. However, in practice the question has been long settled in favor of the laryngoscopic method by the patients themselves, who prefer to be treated in this way rather than trust to opening of the larynx. Semon's statistics up to 1888 include 8216 tumors which were operated upon endolaryngeally, whereas the number of laryngotomy cases since then has been about 200. The author occupies the same position that he took in 1878 in his paper "Laryngotomy for the Removal of Intralaryngeal New Growths." This view was based upon impartial examination of the experience that could be collected up to that time. Laryngoscopic methods deserve preference when they can be made use of. Opening of the larynx is indicated only when a skilled laryngologist is unable to remove the new growth through the natural opening. The task put upon laryngoscopic methods has been rendered greater since the introduction of cocaine. The greatest obstruction to laryngoscopic interference has been removed by this anæsthetic. Surgeons are no longer obliged to rely upon skilful assistance from the patient, which could oftentimes be achieved only after long preliminary practice. The sensitiveness and awkwardness of the patient oftentimes gave rise to failure. Besides this the technical demand on the operator has been lessened to such an extent that the operation may successfully be performed by hands less practised and skilled than formerly. With the aid of cocaine anæsthesia the author has removed many papillomata of the larynx with a single introduction of the instrument.

Those cases are extremely rare in which laryngotomy is necessary for the removal of benign tumors of the larynx. Concerning the conditions in adults, no individual absolute indication for laryngotomy can be stated, neither regarding the situation, the volume, the consistence, nor the method of attachment of the tumors, because tumors of every conceivable variety have been successfully operated upon by endolaryngeal methods. Only when several unfavorable factors are present at the same time will removal through the natural opening seem hopeless from the first. When the tumor is situated below the glottis, conditions are especially unfavorable. This also applies to the lateral ventricle. Although only 3 to 5 per cent. of the cases are found in this region, a large number of such tumors, even when of considerable size, have been removed through the mouth. It is to be presumed in cases of this sort that the mass has a more or less pedunculated base. Large subcordal and ventricular tumors with a broad base always demand laryngotomy. The same applies when the tumor is of dense consistence, whereas if the position is favorable dense fibroma and even enchondroma of the laryngeal cartilages (Störk) may be removed through the mouth by means of a curved knife, cutting-forceps, or with a hot wire loop.

Multiple papillomata must oftentimes be treated by laryngotomy on account of their tendency to recur, as this method allows of radical removal. Nevertheless, experience shows that the percentage of cures is lower with laryngotomy than with the endolaryngeal method. This will not surprise anyone who is familiar with both methods, because the operation must be done at one sitting with laryngotomy, whereas it may be done in stages if the less radical method is used. Individual excrescences may be removed one after the other, even the little particles left behind, and the new growths that spring up. It is advisable in any case of single or multiple papillomata to try to treat first with endolaryngeal methods. The author prefers to use a wire loop for the removal of papilloma and to cauterize the stump with a galvano-cautery. Other authors recommend for this purpose chromic acid or lactic acid. (Schäffer, E. Schmidt.)

It is quite evident that in children the difficulty of operating with a mirror is increased by the small calibre of the child's larynx, and especially because of the lack of assistance, or even resistance. Nevertheless these obstacles may be overcome with patience and tact in handling children. Even in children under four years of age the operation in a number of cases has been done through the mouth with complete success. If operating with a mirror is not successful, Kirstein's spatula may give the desired result. An anæsthetic may then be used. The author has removed papillomata in children repeatedly with this instrument and has also made use of Voltolini's sponge, which renders a mirror unnecessary and removes large numbers of papillomata at a time.

If endolaryngeal methods fail, then laryngotomy is justifiable. One should, however, consider well, because this method cures only in about a third of the cases, and cannot be repeated when the growth recurs, on account of the danger of damaging the voice. It has, however, been done seventeen times on one child. Laryngotomy should be confined to severer cases, and not done in children if possible during the early years of life, when the results of this operation are especially unfavorable. Tracheotomy should be resorted to if there is difficulty in breathing, especially as this will give time to try again the endolaryngeal treatment. In same cases it is possible to remove a papilloma with a laryngeal sponge through the dilated opening in the trachea. Sometimes papillomata do not show any tendency to recur after tracheotomy and may disappear completely in the course of time, as the author has observed. The author's statistics bearing on the operations for papillomata of the larynx in children up to 1878 have recently been carried up to 1896 by Rosenberg. The figures are as follows:

Laryngotomy was performed 143 times in 109 children; 11 were operated on twice, 3 children 3 times, and 1 child 17 times. Fifty-two of the children were under four years of age; 20 died mostly from suffocation with recurrent papillomata; 43 showed recurrences after repeated operation; 40 were cured—*i. e.*, 36 per cent.—and 10 showed disturbance of the voice.

Eighty-eight children, 13 of whom were under four years of age, were treated by endolaryngeal methods: 3 died, 1 of suffocation, due to recurrence; 40 were cured—*i. e.*, 45 per cent.—and 16 relieved. The final result unknown.

Finally, there remain to be considered the special indications for the different methods of laryngotomy, the technic of which will be given in the following paragraphs of this section.

1. Total laryngotomy or thyrotomy. The larynx is divided longitudinally in the region of the thyroid cartilage. The thyroid alone may be split or the incision may be carried through the cricothyroid ligament and the cricoid cartilage as well as the uppermost ring of the trachea. This method is indicated when the upper and middle section of the laryngeal cavity is to be exposed; therefore in tumors that are situated on the false cords and in the lateral ventricles. This method is also used when the tumor is on the vocal cords or in the vicinity of the anterior commissure, or even on the upper surface of the cords. With multiple papillomata, where the entire laryngeal cavity is to be exposed this operation is also indicated. The only danger from interference is in the damage to the vocal apparatus, due to separation of the thyroid cartilage. In a large percentage of the cases there is subsequent hoarseness or loss of voice, which is not owing to the new growth and its removal, but is the result of the thyrotomy itself. It has been suggested that a partial thyrotomy, preserving a narrow strip of cartilage along the upper portion of the thyroid, would be better. (Hüter.) However, if this is done, the cartilage cannot be pulled apart, as the author has repeatedly observed. Even after complete section of the thyroid cartilage the exposure is sometimes insufficient. If the opening is increased downward through the cricoid and the upper rings of the cricoid, the danger of impairing the voice is by no means increased.

2. Partial laryngotomy below the thyroid cartilage. This has the great advantage, compared with thyrotomy, that it is never associated with alteration of the voice, and for this reason is to be preferred in all suitable cases. By this method the lower section of the larynx may be exposed, and it is therefore indicated for the removal of tumors situated along the lower circumference of the glottis. According to the author's experience, based upon more than a dozen operations of this sort, tumors of the vocal cords can be removed in this way only when well circumscribed. The farther backward toward the posterior end of the vocal cords the tumors are situated the easier will be their removal. Partial laryngotomy is not sufficient for the removal of growths on the upper surface or above the level of the vocal cords. Operation will be limited to division of the cricothyroid membrane in a few cases. The length of this ligament varies from 7 to 14 mm. Only very small pedunculated polyps along the margin of the vocal cords or immediately below them can be removed in this way. The author has been able by this method to remove from the lower surface of the right vocal cord a pedunculated papilloma about the size of a small cherry. Ordinarily the opening is not sufficient, and the incision must be continued downward through the cricoid cartilage, as

this will give a better view of the seat of operation and facilitate the introduction of instruments. When the tumors are of considerable size or have an especially broad base, and occupy the lower cavity of the larynx and the upper part of the tracheal tube, then laryngotracheotomy is indicated. This method alone enables rapid and complete removal of the tumor and quite adequately meets the danger of hemorrhage and subsequent inflammatory stenosis.

3. Subhyoid pharyngotomy—*i. e.*, transverse section of the thyrohyoid membrane and opening the lower section of the pharynx immediately above the epiglottis. This method gives access to the entrance to the larynx, and is adapted to the removal of tumors on the epiglottis and in the vicinity of the entrance to the larynx. Inasmuch as these tumors are easily reached by the mouth, this method is rarely used. It is a more extensive procedure than thyrotomy, but there is no danger of damaging the voice. Up to the present time this operation has been performed in 8 cases of benign tumors of the larynx. (Honsell.)

4. A unique method is the submucous removal without opening the laryngeal cavity. The author has been able to remove a fibromyolipoma in this way in a boy thirteen years of age. The growth was situated on the left lateral wall in the middle cavity.

Malignant Tumors of the Larynx.—Malignant tumors of the larynx necessitate more detailed consideration because recently they have become of interest to surgeons and laryngologists.

Sarcomata of the larynx are not so common as carcinoma, the proportion being about as 1 is to 11 or 12 (Sendziak), whereas the proportion with reference to the entire body is as 1 is to 13 (Gurlt). The statistics of Sendziak up to 1894 included 452 operated cases of carcinoma of the larynx and 50 cases of operated sarcoma.

Sarcoma.—It is shown by recent statistics of Bergeat, which contain 103 cases in which the diagnosis was beyond doubt, that primary sarcoma of the larynx is most common between the thirtieth and sixtieth year of life (75 per cent.), and that the male sex is affected in 67 per cent. of the cases. The distribution as regards age and sex was as follows:

Age.		Sex		
		Male.	Female.	Both.
One to ten	years	3	. .	3
Eleven to twenty	"	2	. .	2
Twenty-one to thirty	"	3	3	6
Thirty-one to forty	"	8	10	18
Forty-one to fifty	"	10	9	19
Fifty-one to sixty	"	17	3	20
Sixty-one to seventy	"	5	. .	5
Seventy-one to eighty	"	2	. .	2
Eighty-one to ninety	"	1	. .	1
Total		51	25	76

The immunity of advanced years in women is especially notable; no women above fifty-three years of age were observed to be affected.

The tumor is situated most frequently on the vocal cords (18 times), the false cords 10 times, the epiglottis 12 times, and below the glottis 11 times. Other positions in the larynx were involved in scattered cases only. Sarcoma usually develops as a sharply defined tumor, the consistence of which is more often hard than soft, while the color is more likely to be a light than a dark red. The base is as a rule broad, but the growth is sharply outlined. Rarely the neoplasm appears as a diffuse infiltration, while a pedunculated appearance is still more unusual. This latter form is found chiefly on the vocal cords. The surface of the tumor is usually round, smooth, not infrequently nodular, and may at times be covered with small tabs. Sometimes a sarcoma becomes as large as a walnut.

The neoplasm develops in all directions. Ulceration, however, occurs in very few cases—only about one-tenth—and especially in the portions of the tumor which are exposed to considerable mechanical irritation, such as the region of the vocal cords and false cords and in the sinus pyriformis. The tumor involves the soft parts, but rarely the cartilage, although this may be eroded or even perforated. In spite of the great tendency to extend laterally the tumors never extend beyond the entrance of the larynx. When a tumor develops in the larynx and pharynx, one must be careful about making a diagnosis of primary sarcoma of the larynx. (Bergeat.) Lymph-glands in the vicinity are generally not involved, except in the later stages. According to Bergeat, glandular involvement is present in 15 per cent. of the cases, especially in subglottic sarcoma and in those of the sinus pyriformis, whereas in sarcomata of the interior of the larynx proper the glands are not usually involved. The following histological differences are of importance as indicating the character of a sarcoma of the larynx: spindle-cell sarcoma are the best common, 43 per cent. These develop from the submucosa, and are found almost exclusively on the epiglottis and on the vocal cords. They are possessed of a broad base, but never appear as a diffuse infiltration and resemble fibroma because of their dense consistence and rounded shape. On account of their slow development and the infrequent involvement of glands they are considered decidedly the milder variety of sarcoma of the larynx. Round-cell sarcomata are situated in the lateral walls in the larynx, the vocal cords excepted. They are found chiefly in the sinus pyriformis, in the lateral ventricles, and on the false cords, as well as in the subglottic space. They spread laterally and are of soft consistence, and on account of their rapid growth are a very malignant type. Alveolar sarcomata are, however, still more vicious. These are usually seated in the same places as the round-cell variety and occur as a diffuse infiltration. The clinical picture is that of some grave disturbance on account of extension to the deeper-seated tissues, destruction of cartilage, swelling of the larynx, and involvement of the glands.

Diagnosis.—The diagnosis of sarcoma of the larynx is not easy on account of the many varieties. Dense sarcomata, at least in the early stages, are very difficult to differentiate from benign new formations, whereas medullary sarcomata are difficult to separate from carcinoma. The slight tendency of sarcoma to undergo ulceration is of value in distinguishing the two, as is also the absence of glandular swelling. There is also less local discomfort and less disturbance of the general condition and a much slower course than in carcinoma. The fact that sarcomata do not extend beyond the upper margin of the larynx is also a differential point. Microscopical examination alone will establish a positive diagnosis.

No definite rules can be made with reference to the method of operation in sarcoma of the larynx, because the cases vary so much and experience is so meagre in this direction. Bergeat's statistics include, all told, 90 cases which were operated upon in a variety of ways. The final results are not known in most of these cases.

Treatment.—It would appear reasonable in favorable cases to expect success from an endolaryngeal operation, especially in polypoid sarcoma of the epiglottis and vocal cords. This method has been used in many cases, although in most of them the removal was not complete and recurrence followed. In 3 cases only was there no recurrence for more than one year, and in only 1 case (Gottstein) (fibrosarcoma of the anterior commissure in a boy seven years of age) the patient has had no recurrence for several years. It has therefore not been proved that a permanent cure can be attained after an endolaryngeal operation, because recurrences are observed after a considerable period, such as two, four, five, and nine years. Even in the most favorable cases, just as in sarcoma of other organs, it is necessary to remove the growth very thoroughly with plenty of surrounding healthy tissue. For these reasons there is little ground for questioning whether sarcoma of the larynx belongs to the domain of laryngotomy or laryngectomy. Laryngotomy must be taken into consideration at first as an exploratory operation for the purpose of deciding whether it is necessary to perform a partial or total excision of the larynx, and is thus a preliminary step for the removal of the new growth. Thyrotomy shows permanent cures lasting for more than one year in about one-fourth of the cases, and recurrences in only about one-third and no deaths. Pharyngotomy subhyoidea may take the place of this operation as a preliminary step when the sarcoma is situated near the entrance of the larynx, especially along the epiglottis. Partial excision of the larynx usually includes one-half of the organ and results in a cure lasting for more than one year in about one-half of the cases, with recurrence in one-seventh of the cases and a death-rate of about 20 per cent. Total excision of the larynx, which applies, of course, only to the severest types, shows cures in one-fifth of the cases lasting more than one year, whereas the danger to life is due to the fact that a fourth of the cases succumb to the operation itself. The details of the results of operation for sarcoma of the larynx may be found in the accompanying statistics of Bergeat, including three of Gluck's operations.

	Endolaryngeal operation.	Thyrotomy.	Pharyngotomy subhyoid	Partial excision of larynx.	Complete excision of larynx.	Total.
Cure three years or over	1	2	. .	4	1	8
Cure one to three years	3	4	1	4	2	14
Cure less than one year	6	9	2	2	4	23
Recurrence or incomplete removal	24	7	2	2	5	40
Fatal result	.	. .	. .	3	4	7
	34	22	5	15	16	92

Carcinoma.—Cancer of the larynx is found especially in the second half of life, for only 16 per cent. of the cases are under forty years of age. The sixth decade is the one most frequently affected (39 per cent.), and the fifth next with 25 per cent. The seventh decade shows twice as many cases as the fourth. (Sendziak.) According to the statistics of Sendziak, which include 479 cases, the distribution in the various decades is as follows:

Age.		
One to twenty years	5	cases.
Twenty to thirty "	22	"
Thirty to forty "	41	"
Forty to fifty "	121	"
Fifty to sixty "	188	"
Sixty to seventy "	80	"
Seventy to eighty "	17	"
Eighty to ninety "	5	"

Sex plays an equally important part, inasmuch as males are affected six times as often as females. (Sendziak.) There is no explanation of this fact, nor of the observation that this disease, contrary to carcinoma of some other organs, affects individuals in the higher walks of life more than the poor and hard-working classes.

Cancer of the larynx is quite rare compared with cancer of other organs. Gurlt's statistics show but 0.5 per cent. of the total cases of cancer. Carcinoma may be situated in any part of the larynx, although it is found more frequently in certain portions. It is customary, after the example of French authors, to distinguish internal and external cancers of the larynx according to whether they are situated inside or outside of the laryngeal cavity—*i. e.*, surrounded by the thyroid and cricoid cartilages or not. If this subdivision be accepted, it will be found that cancer of the interior of the larynx is more than twice as common as those of the outside. The internal variety is found most often on the vocal cords, the false cords, and on the plica interarytenoidea, whereas the external variety are generally found on the epiglottis, the pharyngeal surface of the posterior wall, and on the aryteno-epiglottidean folds. The growth is situated more than twice as often on one side of the larynx than on both at the same time, the right and left sides being involved in about an equal number of cases. Sendziak's statistics include 273 cases in which the seat of the new formation was known. The distribution was as follows: internal cancer of the larynx: vocal cords, 170; false cords, 23; plica interarytenoidea, 15; lateral ventricles, 7; subglottic space, 7; in all of these places at the same time, 12; on the laryngeal and pharyngeal surface of the posterior wall at the same time, 33. External cancer of the larynx: epiglottis, 24; pharyngeal surface of the posterior wall, 18 (13 in women); plica aryteno-epiglottidea, 13; sinus pyriformis, 7; in several places at the same time, 7. It is therefore evident that in the majority of instances cancer of the larynx affects the regions covered with squamous epithelium, and for this reason squamous epithelial cancer is the most prevalent type and is found in about one-half of the cases, while cylindrical epithelial cancer and adenocarcinoma are much less common.

In the early stages cancer develops as a circumscribed infiltration in the mucous membrane or as a small protruding growth. This infiltration appears at first as a flat circumscribed thickening of the submucous tissue, and is covered with intact epithelium or has a more or less excoriated surface. This small growth has a broad base, but it may be pedunculated in exceptional cases. The growth appears as a smooth or granular nodule, like a wart, or as a rough excrescence. This early type may develop very slowly, and may even continue for years before it begins to increase appreciably in size. The subsequent growth, however, is rapid. In other cases the new formation may extend rapidly in all directions. In the later stages cancerous infiltration or ulcerative degeneration may predominate. The early infiltration, at first circumscribed, extends to the surrounding tissues and loses its sharp outline. The reactive swelling of the neighboring tissues, which become inflamed and œdematous, favors this condition. Sometimes the tumor increases laterally, sometimes it extends to the deeper parts, and sometimes it develops equally in all directions. In exceptional cases carcinoma has been observed to resemble polyps or be pedunculated. The mass of the neoplasm is then possessed of a smooth or uneven surface, irregular, tab-like, or nodular. Ulceration takes place sooner or later according to the tendency of the particular growth to disintegrate. In some cases even the early circumscribed infiltration presents the appearance of a sharply outlined ulcer with uneven, ragged base and punched-out margin. In other cases the tumor may attain to considerable size before ulceration takes place. The ulcers either extend over the surface only or may penetrate the interior of the growth and give rise to extensive clefts and deep, crater-like openings. Not infrequently new masses of tumor develop as nodular or ragged growths in the base of an ulcer.

The cartilage is surrounded or perforated, and at times purulent perichondritis and necrosis are found in connection with extensive ulcerations. The neoplasm may extend to the skin or into the substance of the thyroid gland, or may even perforate the skin, causing crater-like ulcers.

Extension into the interior is apt to follow the squamous epithelium (B. Fränkel), which means that it progresses from one side to the other, usually along one of the vocal cords, past the anterior angle of the glottis, or along the posterior wall to the other vocal cord (circular cancer of the larynx). Cancer extends in the same way from the laryngeal surface of the posterior wall through the incisura interarytenoidea to the pharyngeal surface. Sometimes it extends from the aryteno-epiglottidean folds and the epiglottis to the pharynx itself, to the sinus pyriformis, the œsophagus, or to the tongue, and from the lower section of the larynx to the trachea. Involvement of neighboring lymph-glands is not always constant, and seems to be much more common with external than with internal cancer of the larynx, which is explained by the scarcity of lymph-vessels in the wall of the laryngeal cavity proper. Palpable glands are situated usually along the inner margin of the sternomastoid at the level of the larynx, and after extension of the growth to the pharynx and tongue the submaxillary lymph-glands may also be involved. Cancerous metastases in other organs following primary carcinoma of the larynx have been observed in a few cases only.

Secondary cancer of the larynx is extremely rare compared with the primary type which has just been considered. If a few exceptional cases of metastatic carcinoma of the larynx are taken into consideration, secondary cases are chiefly due to direct extension of the carcinoma from the immediate neighborhood, especially from the tongue, the pharynx, or the thyroid. It is self-evident that appearances may lead one to suspect that a primary carcinoma of the larynx has extended to the neighborhood, so that it is at times not easy to differentiate.

Symptoms.—The clinical signs of cancer of the larynx depend, especially in the early stages, upon the localization. Internal carcinomata are usually seated along the margin of the glottis. The first and often the only difficulty, although continuing for more than a year, is a disturbance of the voice, perhaps only hoarseness. Gerhardt considers that chronic hoarseness without cough developing in individuals of middle or advanced age is suggestive of carcinoma. This hoarseness increases slowly, but does not always develop to complete loss of voice. It is caused either by the tumor or the ulcer which attacks the vocal cord itself, or by the growth pressing upon the same from below or above. Sometimes the vocal disturbance is due to immobility of one of the cords, especially if the cancerous infiltration has involved and destroyed the arytenoid joint, the corresponding muscles, or the motor nerves.

External carcinomata betray themselves because of the resulting difficulty in swallowing. This symptom may increase rapidly, corresponding to the rapid disintegration of the tumor, which results secondarily in disturbances of nutrition because of interference with the act of swallowing. Difficulty in breathing does not develop as a rule until later, when the increasing growth gives rise to stenosis. This may sometimes increase slowly during many months, or may progress very rapidly, so that within a few weeks the dyspnœa is severe and there is danger of suffocation. The inflammatory œdema or perichondritis still further aggravates the situation. Sometimes rapid disintegration of the cancer limits the annoyance from stenosis. The pain present, at least in the later stages of the disease, is considered more or less characteristic. This accompanies swallowing, coughing, and talking, or may appear spontaneously in sharp attacks and follows the course of the auricular branch of the pneumogastric nerve to the ear and occiput. Finally, there remain to be mentioned two other symptoms that indicate rapid disintegration of the tumor: the expectoration of foul secretion and more or less severe hemorrhage. External swelling and involvement of the glands are not always present.

The general condition not infrequently remains undisturbed for a considerable length of time. Only in advanced stages after ulceration does the general condition begin to fail, especially when dysphagia, dyspnœa, and lancinating pains torture the patient. Death follows in the average case after about three years, either suddenly from suffocation or aspiration pneumonia, or slowly from cachexia or marasmus due to insufficient nutrition.

Diagnosis.—The diagnosis is difficult in the early stages, even to an experienced observer. In the later stages the symptoms are usually sufficiently pronounced to suspect the presence of a malignant growth. The diagnosis is based, of course, on the conditions found by laryngoscopic examination, which cannot be considered here more in detail. If the carcinoma is in its early stages and appears as a circumscribed infiltration of the mucous membrane, then it must be differentiated from syphilitic and tuberculous infiltrations. When the beginning carcinoma presents itself as small tumors, these may be confounded with benign growths, papilloma, fibroma, and sarcoma. A slight redness surrounding the small growth will serve as a differential characteristic, and the slight mobility and later the immobility of the corresponding vocal cord will be suggestive of a malignant growth. (Semon.) An ulcerated condition of the surface is also in favor of carcinoma. A fact which cannot be too well remembered as regards the laryngoscopic picture is that the extent of the new growth, as far as the picture in the mirror is concerned, always seems much less than what is found on direct inspection after section of the larynx.

The microscopical examination is of the greatest value in doubtful cases. A specimen for examination may be obtained endolaryngeally, and will often decide the question, provided the excised bit is not too small or too flat. An examination of this sort, however, is not always positive, as shown by a number of cases in which a diagnosis of benign and malignant growth was made by different examiners all using one and the same piece of tissue. Semon is probably correct in making the physician responsible for the diagnosis rather than the pathologist. The former must take into consideration the clinical suspicion of malignancy even when the microscopical examination is in favor of a benign growth. It is absolutely necessary to make use of all diagnostic factors, the age and sex, examination for evidence of syphilis and tuberculosis, examination for tubercle bacilli in the sputum, preliminary administration of potassium iodide, and, if needs be, thyrotomy for the purpose of directly inspecting the growth and removing a piece for microscopical investigation.

Prognosis.—The prognosis in cancer of the larynx up to thirty years ago was absolutely hopeless, and even until quite recently was very unfavorable. Left to itself this disease invariably terminates fatally within a few years. Attempts at radical removal have been successful in a comparatively small number of cases. Up to the year 1894 only 37 patients out of 451—*i. e.*, 8 per cent.—were permanently cured, which means that there was no recurrence for more than three years after operation. (Sendziak.)

Of late the chances have been considerably improved. Aside from the modern advances in operative technic and treatment of wounds which diminish the mortality, more permanent results have been obtained due to the effort to establish an early diagnosis of cancer of the larynx and excise the same as early as possible while it is a purely local disease. Involvement of the lymph-glands takes place comparatively late in internal cancer, so that there is a much better chance for a radical cure by operation in these cases than in external carcinoma. Internal carcinomata of slight extent confined to the vocal cords offer the best prognosis. The early operation has the great advantage that it is not necessary to perform a total excision of the larynx, but that simple section or partial resection of the larynx will be sufficient.

The prognosis as regards restoration of function in the larynx is intimately connected with the early diagnosis. After thyrotomy, and even after partial resection of the cartilage at times, recovery may take place and free respiration through the mouth be preserved. Sometimes even the voice can be restored to a greater or less extent. A brilliant example of this is the success following excision of a cancer of one vocal cord with total laryngotomy, which the author performed twelve years ago on a colleague. After the cord-like strand of scar-tissue which had developed in the place of the vocal cord, was removed with the surrounding tissue, the voice returned to such an extent that the gentleman has since been able to continue his didactic activity uninterrupted.

Total excision of the larynx deprives the patient of free respiration through the mouth, destroys the voice, and obliges the individual to wear a tube or artificial larynx. This condition is pitiable, but that life is not worth living as claimed by some laryngologists is not true according to the author's experience. Even in apparently hopeless cases in which the entire larynx and portions of the neighboring tissues have been removed, the condition may be bearable subsequently; swallowing is undisturbed and breathing takes place without a tube in the tracheal wound.

Treatment.—The radical treatment of cancer of the larynx is somewhat more hopeful than similar operations in other regions of the body, because the affection can be detected as a rule quite early, and can usually be seen with a mirror. Just as in all other types of carcinoma, the chances of successful treatment depend upon an early diagnosis and early operation. The various methods of radical treatment are as follows: 1. Excision endolaryngeally; 2. Excision by thyrotomy; 3. Excision by means of pharyngotomy below the hyoid bone; 4. Partial excision of the larynx; 5. Total excision of the larynx. Views regarding the indications for these methods have undergone instructive changes during the last thirty years. In the seventies the absolutely unfavorable results of endolaryngeal operations, as well as of excision after thyrotomy (P. Bruns), gave rise to the opinion that these methods were useless. Consequently all hope was placed in excision of the larynx, especially in total excision, which was considered indicated in all cases of cancer of the larynx as soon as the diagnosis was certain. (Foulis, Czerny, International Congress, London, 1881.) During this decade 200 excisions of the larynx were performed, 124 total, and 39 thyrotomies (statistics of Sendziak), and it was shown that the mortality and the chances of recurrence after total excision were about double those of partial excision. This was because the latter included mostly cases which were not so far advanced. During the last decade total excision has been replaced more and more by resection and thyrotomy which were formerly unsuccessful because performed in cases that had advanced too far. Surgeons have gradually become convinced that a cure from cancer of the larynx is to be found only in an early diagnosis and an early operation.

1. The endolaryngeal operation is recommended by some laryngologists, when the carcinoma is small and easily reached (Fränkel, Jurasz, Bresgen, Krieg), because it is associated with the least amount of danger to life and to the voice. Fränkel reports 4 cases from his own practice and 3 others in which there was no recurrence after more than three years. It is thereby proved that recovery may take place after endolaryngeal interference, although this is very unusual, because it presupposes the simultaneous presence of numerous favorable conditions. The large number of unsuccessful attempts are, of course, not reported. Attempts of this sort increase the rate of growth, the favorable period for external operation is missed, and the outlook becomes less encouraging. Looked at from this point of view, the author considers, just as do Schrötter and Semon, that the endolaryngeal method is insufficient and to be condemned in cancer of the larynx, because as a rule it is harmful to the patient.

2. Thryotomy or complete laryngotomy is the normal procedure in the early stages of carcinoma when the growth is confined to the interior of the larynx and has not extended laterally to any great extent. Besides this, this method may serve as an exploratory incision in doubtful cases to determine the extent of the disease, and may be followed by partial or total excision of the larynx. The advantages of the operation consist in the slight amount of interference, associated with

but moderate danger to life, considering the advanced age of most patients. It also shows relatively many cases of radical cure and promises of the most favorable functional results. Breathing is unimpeded, so that most patients are not obliged to wear a tube; the voice is more or less preserved in some cases, because a fold-like scar develops in the place of the excised cord. This explains how an academic instructor operated upon twelve years ago for cancer of the larynx still continues his didactic work, and how a patient operated upon by Chiari is still able to read aloud in public. One patient operated upon by Hahn followed his occupation as Judge for six years.

The statistics of Sendziak are not adapted to indicate the results of thyrotomy in cancer of the larynx, because they include the total number of cases from 1851 to 1894. Only the cases of the last decade give any idea of the value of this operation, inasmuch as they represent the present views as regards indication and technic. The recent statistics of Schmiegelow, containing 49 cases from 1890 to 1896, to which the author added 11 cases from 1890 to 1898, are more appropriate. A comparison between both statistics will show the advances of modern times.

RESULTS OF THYROTOMY IN CANCER OF THE LARYNX.

	1851 to 1894.		1890 to 1898.	
Cured over three years .	8 (8.7 per cent.)	20 (21.7 per cent.)	11 (18 per cent.)	22 (36.6 per cent.)
Cured one to three " .	12 (13 ")		11 (18 ")	
Cured under one year . .	8 (8.7 ")		12 (20 ")	
Recurrences	49 (53.3 ")		17 (28 ")	
Death due to operation .	9 (9.8 ")		9 (15 ")	
	86		60	

Semon has had very favorable results: 12 thyrotomies between 1881 and 1898 for malignant tumors of the larynx with 9 cures; 6 of these for more than three years; 1 doubtful recurrence, and 2 deaths. The cured cases are in the best of health and wear no tubes; 6 have a surprisingly good voice, and the others a feeble but still useful voice. As regards the technic of the operation, it should be emphasized that local anæsthesia alone should be used instead of general anæsthesia. (Kocher.) A 1 per cent. solution of cocaine is injected along the line of incision into the soft part, and after opening of the larynx the mucous membrane is painted with a solution of cocaine and antipyrin, 5 parts each, distilled water 100, and carbolic acid 1 part. This does away with the reflex attacks of coughing and attempts at swallowing, and diminishes the amount of hemorrhage from the mucous membrane. Tracheotomy is usually done first and a tampon-tube introduced. The author prefers, as does Kocher, to have the patient in an inclined position with the head low, so as to prevent aspiration of blood. This also prevents the entrance of pharyngeal mucus into the larynx, which otherwise must be held back by packing the lower section of the pharynx. The incision extends throughout the entire larynx down into the trachea so as to give sufficient room. After pulling the cartilage apart the tumor is excised down to the perichondrium with the aid of artificial light. The wound is touched with the galvanocautery if necessary and iodoform may be rubbed in. Packing with iodoform gauze is unnecessary. The halves of the thyroid cartilage are united in the upper portion of the wound by sutures and an ordinary tracheal tube inserted, which may be removed after a few days. It is usually possible to swallow liquids after the first day.

3. Pharyngotomy subhyoidea. This method is best adapted to those cases of external cancer which are situated on the epiglottis and the aryteno-epiglottidean folds. It does not give sufficient room for extensive excisions, and is associated with marked danger to life, due to aspiration pneumonia and sepsis.

Sendziak's statistics, which contain only 8 cases, have been enlarged by Honsell with 25 more. The cancer was situated on the epiglottis 8 times, on the aryteno-epiglottidean folds 5 times, and 6 times in both places at the same time. Recovery took place in 9 cases (3 lasting for more than three years, 1 two years, and 5 less than one year), recurrences in 5 cases, and fatal termination in 10 cases (40 per cent.), due to pneumonia, sepsis, and secondary hemorrhage.

4. Partial excision of the larynx is indicated when a carcinoma has extended to the cartilage itself, although not very extensively. One-half of the larynx is removed in the ordinary typical way, or greater or lesser portions of cartilage are removed from one or both sides. In the latter cases a considerable or even the greater part of the larynx may be removed, so that the operation resembles closely a total excision. Partial excision has replaced total excision in a considerable number of cases, as shown by the fact that the latter operation has not been frequently performed during the last decade. Typical unilateral resection is more often made use of than atypical partial resections. The results vary corresponding to the varying extent of these resections, and the danger of life, taking all in all, is not insignificant (17 per cent.), and is to be explained by the advanced age of the patient operated upon. Pneumonia is almost always the cause of death. In those that recover the functional result is sometimes surprisingly good. Most patients breathe well and are not obliged to wear a tube. They speak with whispered voice, or with audible, sometimes even loud intonation, because one or both excised vocal cords have been replaced by folds of scar-tissue which act as an artificial glottis.

The technic of the operation is very much like that of thyrotomy. Local anæsthesia and a low position of the head are an advantage. The after-treatment consists in packing the wound with iodoform gauze, leaving an ordinary tracheal tube in place, and liquid diet.

The following table represents the results of partial excision of the larynx performed since 1890, compared with the figures in Sendziak's statistics from 1876 to 1894. Comparison makes evident the modern advances.

RESULTS OF PARTIAL EXCISION OF THE LARYNX FOR CARCINOMA.

	1876 to 1894.		1890 to 1898.	
Cure, lasting three years .	12 (10.9 per cent.)	25 (22.7 per cent.)	13 (12 per cent.)	29 (27 per cent.)
Cure, lasting one to three years	13 (11.8 ")		16 (15 ")	
Cured under one year . . .	21 (19 ")		25 (23 ")	
Recurrences	33 (30 ")		33 (31 ")	
Death following operation	29 (26.3 ")		19 (17 ")	
	108		106	

5. Total excision of the larynx is indicated in all cases of cancer of the larynx in which partial excision is not sufficient and in which a cancer may still be operated upon. The tumor is operable just as in cases of cancer elsewhere when there is a chance that the growth may be entirely removed and when the patient is strong enough to stand the operation. No other indications apply, because if the patient is not operated upon he is sure to die. For this reason it is not justifiable, as is too frequently done, to deny operation when the carcinoma has exceeded the limits of the larynx. That radical interference is reasonable in these cases is shown by the fact that permanent cures have been repeatedly obtained under very disadvantageous conditions. Excision of the larynx with removal of part of the pharynx, œsophagus, base of the tongue, trachea, thyroid gland, and masses of lymph-glands, go to make about one-fourth of all the cases. Recently Gluck removed in a man fifty-four years of age the entire larynx with the epiglottis, five rings of the trachea, the hyoid bone, a tumor of the base of the tongue, the lateral wall of the pharynx, a piece of the œsophagus, masses of glands in both sides of the neck, and large pieces of infected skin. The patient has been perfectly well for several years, looks healthy, can speak well, swallows normally, and attends to his business. The author excised the entire larynx, five rings of the trachea, the upper section of the œsophagus, half of the thyroid gland, and the patient is still living and in good health after eight years.

The success of this operation depends largely upon the seat and extent of the carcinoma. The results are much more favorable in internal cancer, inside of the cartilage framework of the larynx, and where there is no glandular involvement. The danger to life is not much greater than with resection and thyrotomy, owing to improved operative technic and treatment of wounds. Whereas formerly nearly half of the patients operated on died, at the present time only about one-fifth succumb to the operation itself. The cause of death is usually pneumonia. The number of permanent cures lasting at least one year is at the present time twice what it used to be (25 : 12.8 per cent.). The functional result is also decidedly better owing to improvements in technic, and the subsequent condition of the patient is much more satisfactory. The stump of the trachea is sewed in the lower angle of the skin-wound (prophylactic resection of the trachea after Gluck and Zeller). The danger of aspiration pneumonia following the entrance of food, saliva, mucus, and secretions from the wound is avoided, and it is possible to keep the tracheal wound open so that it becomes unnecessary to wear a tube with all its annoyance and dangers. It is of great advantage to shut off the pharynx from the wound by a plastic, so as to guard against infection and aid swallowing. The anterior pharyngeal wall and the œsophagus-wall are united with suture. (Bardenheuer, Rotter.) A patient operated upon in this way does not wear a canula or an obturator, and swallows like a normal individual. The voice only is absent, owing to insufficient communication between the trachea and the pharynx. Gluck's phonation apparatus obviates this defect to some extent. All demands have been recently met in a very simple way by the method recommended by Föderl. After removal of the larynx the continuity of the air-tube is restored by pulling the trachea up and fixing in place by means of a circular suture.

The following table indicates the results of total excisions of the larynx performed since 1890, compared with Sendziak's statistics from 1873 to 1894:

RESULTS OF TOTAL EXCISION OF THE LARYNX FOR CARCINOMA.

	1873 to 1894.		1890 to 1898.	
Cure, over three years .	11 (5.8 per cent.)	24 (12.8 per cent.)	7 (8.6 per cent.)	21 (26 per cent.)
Cure, one to three " .	13 (6.9 ")		14 (17.4 ")	
Cure, under one year . .	24 (12.8 ")		26 (32 ")	
Recurrence	61 (32.4 ")		19 (23.4 ")	
Deaths due to operation	84 (44.7 ")		15 (18.5 ")	
	193		81	

Considering these results as regards the danger to life, the permanent cures, and the condition of those cured, it is not justifiable for many laryngologists to refuse to perform total excision of the larynx. Individuals with cancer of the larynx will in future escape this disfiguring operation more frequently because the diagnosis can be made earlier and be followed by immediate surgical interference.

Finally, it may be well to add a table including all operations done for cancer of the larynx since 1890, so as to obtain some idea of the value of the special methods.

	Thyrotomy.		Pharyngotomy subhyoidea.		Partial excision of larynx.		Total excision of larynx.		Total.	
Cure lasting 3 years .	11 (18%)	22 (36.6%)	3	4 (16.6%)	13 (12%)	29 (27%)	7 (8.6%)	21 (26%)	34 (12.5%)	76 (28%)
Cure lasting 1 to 3 yrs.	11 (18%)		1		16 (15%)		14 (17.4%)		42 (15.5%)	
Cured under 1 year . .	12 (20%)		5 (20%)		25 (23%)		26 (32%)		68 (25%)	
Recurrences	17 (28%)		5 (20%)		33 (31%)		19 (23.4%)		74 (27%)	
Death due to operation	9 (15%)		10 (40%)		19 (17%)		15 (18.5%)		53 (19.5%)	
	60		24		106		81		271	

It is surprising, as shown by the above figures, that the death-rate is about the same in the slight operations as in the more severe. It is about as great after thyrotomy and partial excision of the larynx as after total excision, and varies between 15 and 18 per cent. Death is usually due to aspiration pneumonia, and the danger of having a communication between the deep air-passages and the wound is common to all operations. In total excisions of the larynx this disadvantage has been somewhat overcome by resection of the trachea, and recently by the use of a circular suture, whereas partial interference is open to the same objections as before. It is to be hoped that advances in the technic will be made in this direction in the near future.

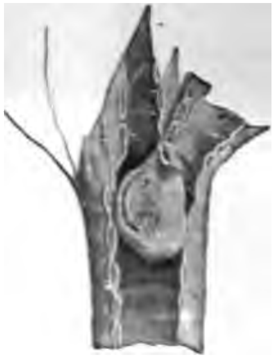
Still, the above figures show gratifying advances in the operative treatment of cancer of the larynx, for up to within quite recent years the prognosis was hopeless, and these results should stimulate medical practitioners to urge a radical operation in every case of cancer of the larynx the moment a diagnosis is established.

New Growths of the Trachea.

Tumors of the trachea are extremely rare compared with those of the larynx. This is evidently because the trachea, as a simple rigid smooth tube, is more protected from functional irritation and external damage than is the larynx. Only 147 cases (Bruns) have been reported, so that new growths of the trachea constitute but 1 per cent. of those in the larynx. The author's experience is with reference to 7 tumors of the trachea and 300 tumors of the larynx. M. Schmidt observed 748 new growths in the larynx and 3 in the trachea out of 42,635 cases of disease of the upper air-passages.

Among the benign new growths of the trachea, fibroma and papilloma are almost exclusively to be considered, just as in case of the larynx. The fibromata develop as isolated pedunculated polyps from the size of a pea to that of a hazelnut, and are most frequently situated in the lower, very rarely in the middle third of the trachea. Papillomata are rarely confined to the trachea. They are usually present in the larynx at the same time, only a few extending into the trachea. Sometimes, however, the trachea may be covered to a considerable extent, or even throughout its length, with many isolated or confluent masses of papilloma. Papillomata of the trachea, just as of the larynx, are found most often during childhood and present the same tendency to recur after operative interference.

FIG. 75.



Lipoma of trachea. (Rokitansky.)

Osteomata are not infrequently found in the trachea as a peculiar typical form, and have never become of practical importance. They consist of deposits of cartilage and bone in the mucous membrane, and form plates of varying size with irregular surface. The number is sometimes great, and they may extend over the entire tube while the larynx is not involved. The internal surface of the tube presents a rough, granular appearance. Now and then individual bands or plates encroach upon the lumen of the trachea. These osteomata, according to the investigations of Mischaikoff, are the result of some anomaly of development.

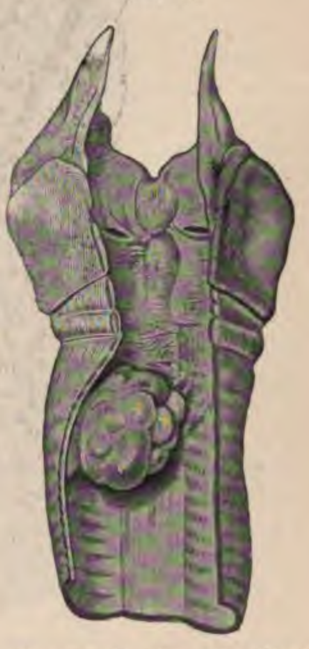
Lipoma (Fig. 75), enchondroma, adenoma, lymphoma, and thyroid tumors have also been found now and again in the trachea.

Intratracheal thyroids are of especial interest, although only 9 cases have been reported (4 personal observations, and 1 each by v. Ziemssen, Roth, Paltauf, Baurowicz, and Freer). These growths appear as rounded tumors encircling the tube and attached to the upper part of the trachea by a broad base. They are usually adherent to the lower section of the larynx at the same time, and occupy one lateral wall and part of the posterior wall. These tumors may present an annular appearance and occupy the entire circumference of the wall, extending upward to immediately below the glottis and downward as far as the fourth tracheal ring. (Freer.) They always develop slowly and appear between the fifteenth and fortieth year. Their development is explained by supposing that normal thyroid tissue penetrates between the cartilage-rings from without as far as the mucous membrane of the trachea. (Paltauf.)

Malignant tumors of the trachea are extremely common compared with benign tumors; 30 per cent. of the total number of cases, and 37 per cent. if the clinically insignificant osteoma be excluded. In the larynx, on the other hand, they constitute but 12 per cent. of all cases. When a tumor of the trachea is found, one would be much more inclined to suspect a malignant growth.

Primary sarcomata are extremely common compared with carcinoma (1 to 2, in the larynx 1 to 12). They form round tumors, usually with a broad base, situated on the posterior and lateral wall of the trachea, that develop slowly and may attain considerable size, occupying at times almost the entire lumen of the tube. (Fig. 76.) There is no tendency to ulceration, perforation of the tracheal walls, or involvement of lymph-glands.

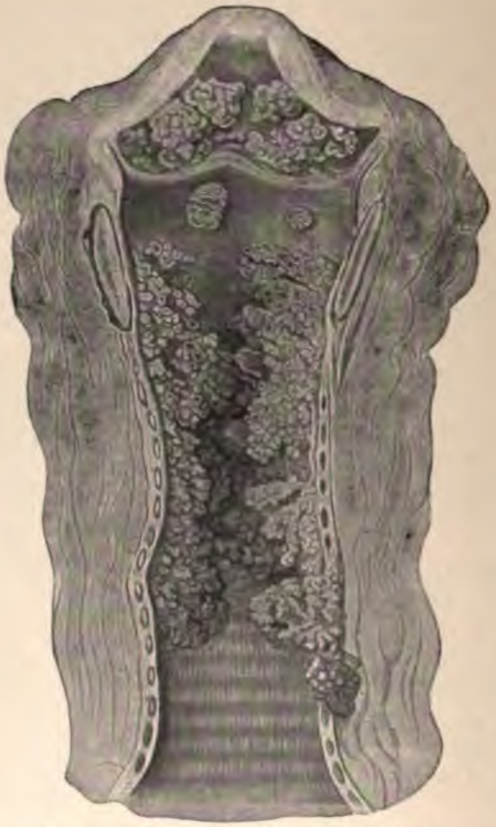
FIG. 76.



Sarcoma of trachea. (Schrötter.)

Primary carcinoma of the trachea is extremely rare. Extension from the neighboring organs is much more common, for instance, from the larynx, the œsophagus, the thyroid glands, and the bronchi. The usual seat of primary cancer of the trachea is the upper section of the tube or the lower part immediately above the bifurcation, whereas the middle third is rarely attacked. Sometimes the new growth covers a considerable area, and in one case observed by the author ten tracheal rings were involved. The posterior wall with its abundant glands is more often affected, whereas the cartilaginous anterior wall is usually exempt. For this reason there is no tendency to annular growths. Carcinoma sometimes appears as a flat infiltration of the mucous membrane or of the entire tracheal wall, sometimes as a circumscribed nodular, irregular tumor, and sometimes as a distinct papillary growth. (Fig. 77.) The tumor as a rule remains localized for a relatively long period, and metastases in the lymph-glands and distant organs have been but rarely observed.

FIG. 77.



Carcinoma of trachea and larynx. (Schrötter.)

Symptoms.—The symptoms produced by these tumors of the trachea are in many respects like those of stenoses of the trachea due to other causes which have already been considered. It is more or less characteristic of these neoplasms that symptoms of stenosis appear rather late when the tumors are of considerable size and produce marked diminution of the lumen. They may be recognized by the slowly developing dyspnœa, affecting inspiration and expiration equally and prolonging both. Audible stridor, the intensity of which corresponds to the degree of stenosis, is also marked. Contrary to laryngeal stenosis, the voice remains unchanged, and the flexion of the head and slight respiratory disturbance in the region of the larynx are also more or less characteristic. (Gerhardt.)

Diagnosis.—If the diagnosis of stenosis of the trachea can be made and compression from without excluded, tracheoscopy will decide whether a new growth or a tuberculous or syphilitic condition is the cause. Laryngoscopic examination will oftentimes give sufficient information, and in children examination with Kirstein's spatula under anæsthesia may be valuable. It is oftentimes difficult to estimate the distance to the seat of the tumor in the trachea. As a rule, one is apt to overrate this. Information regarding the consistency and mobility of the tumor may be obtained with a laryngeal sound.

Treatment.—Operative treatment in tumors of the trachea shows brilliant results. Untreated the condition leads to death from suffocation. In 7 cases operated upon by the author the results were all favorable.

Palliative treatment in inoperable tumors aims at removal of the dyspnœa either by intubation or tracheotomy. The latter method is as a rule to be preferred because it gives the desired result in the majority of the cases, for most of the tumors are situated in the upper portion of the trachea. When deeper seated, an attempt may be made to get past the stenosis with a long flexible (König) or a jointed (Bruns) tube.

It is sometimes possible to remove the growth by endotracheal operative measures, especially in the case of pedunculated polyps in the upper portion of the tube. The author was able to remove a papilloma from the fifth tracheal ring with a wire loop, and in another case multiple papillomata were successfully removed by the sponge method. As a matter of fact, up to the present time endotracheal interference reaches its limit at the middle of the trachea.

Removal after tracheotomy is in the majority of cases the only reliable procedure. This enables one to attack and remove directly all sorts of benign new growths whether they have a broad base or not. The anterior wall of the trachea is opened to a sufficient extent and a tampon-tube inserted, while the inner surface of the trachea is anæsthetized with cocaine. The tumor is excised with a knife, scissors, or galvanocautery, while the field of operation is lighted with a small electric light. Up to the present time about two dozen operations of this sort have been reported. The author has removed in this manner four intralaryngeal thyroids with permanent result.

There remains to be mentioned excision of cancer of the trachea with resection. This has up to the present time been done only once by the author. A cancer on the posterior wall of the trachea was removed with ten tracheal rings, which gave the patient six years of life.

OPERATIONS ON THE AIR-PASSAGES.

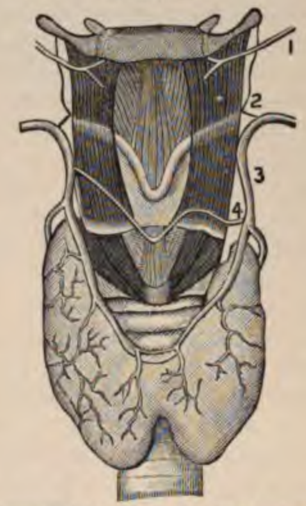
Tracheotomy.—This subject has been considered first, not only because it is the most frequently indicated method, but also because it is of the greatest practical importance of all operations on account of the immediate life-saving result, and because the majority of the other operations demand preliminary tracheotomy.

Indications for Tracheotomy.—Generally speaking, two objects are sought by this operation: restoration of free passage of air, and for the purpose of gaining access to the region below the glottis. Sometimes it is performed for both of these purposes at the same time. The special indications have almost all been considered in the preceding paragraphs, and they will only be enumerated briefly in this connection: 1. Injuries to the larynx and trachea. 2. Foreign bodies in the trachea. 3. Acute inflammatory processes in the larynx and trachea or their vicinity: diphtheria, laryngitis submucosa, œdema, pseudo-croup, perichondritis. 4. Chronic inflammatory processes, tuberculosis, syphilis, scleroma, leprosy. 5. Stenosis from compression, strictures. 6. Neuroses. 7. New growths in the trachea and larynx. 8. Preliminary tracheotomy in operations upon the upper air-passages. It remains to be added, because not considered elsewhere, that this operation is done for asphyxia due to inhalation of gases or in chloroform anæsthesia when artificial respiration without tracheotomy is not successful, or when quantities of mucus accumulate in the trachea and bronchi, which have to be removed by aspiration. Hüter recommends this operation for these same reasons in cases of acute œdema of the lung.

Anatomical Remarks.—The field for tracheotomy is bounded below by the sternum. The upper boundary is the lower margin of the thyroid cartilage because section of the ligamentum conoides and the cricoid cartilage will be considered with tracheotomy on account of the technic, and because of the reasons for which this step is taken. The absolute length of the available space varies in different individuals aside from the differences due to age. The trachea in its course downward is more and more removed from the surface. In adults there is about 3 cm. of soft parts between the skin and the anterior tracheal wall immediately over the sternum; whereas at the upper end near the cricoid cartilage it is immediately beneath the skin and can be easily palpated.

Between the trachea and the skin there are various anatomical structures which influence the technic of tracheotomy. The isthmus of the thyroid gland is first to be considered because it subdivides the operative field of tracheotomy into two sections. Normally the isthmus covers the beginning of the trachea down to the fourth ring and does not extend upward as far as the cricoid, leaving in adults the first tracheal ring partially or wholly exposed. Sometimes the first interspace is free. (Fig. 78.) In children under six years of age, according to Hüter, König, Symington, and others, it almost always reaches up to the cricoid. A tongue-like middle lobe not infrequently extends upward from the isthmus (lobulus pyramidalis). This is usually a little to one side of the median line, and may sometimes extend as far as the hyoid bone. The anatomical position and the frequency of occurrence are explained by the method of development of the thyroid gland (Streckeisen found this condition present in 74 per cent. of the cases). In exceptional cases the isthmus may be absent. The thyroid gland is fastened to the trachea by means of the ligamentum glandulæ thyroidea, the middle one of which (ligamentum thyrolaryngea) alone is of importance in tracheotomy. This extends from the cricoid cartilage downward and divides into two portions which include the isthmus. In children, according to Hüter, it is tense and strong, while in adults it is loose and can be easily removed.

FIG. 78.



Relations of the larynx and trachea and thyroid gland: 1, hyoid branch of the lingual artery; 2, superior laryngeal artery; 3, superior thyroid artery; 4, cricothyroid artery. (Luschka.)

The statements regarding the region occupied by the thyroid gland are of no value in the individual case under normal conditions, and when the surgeon is obliged to operate in regions where thyroid tumors are common, they are misleading. In these countries the field of operation not infrequently may be found encroached upon, even in healthy individuals, because of the more abundant development of the thyroid, than in countries where goitre is not prevalent. Conditions of this sort may render tracheotomy a difficult problem, the solution of which tests the skill of the best trained surgeon. König may be quite right when he explains the contradictory statements of reliable surgeons regarding the difficulty of tracheotomy by assuming that one may operate in regions in which goitre is not common, while others acquire their experience in countries where this disease is prevalent.

Next to the thyroid gland, the bloodvessels are of importance in performing tracheotomy. In the upper section of the field of operation the cricothyroid branch of the superior thyroid artery alone is of importance. This forms in front of the ligamentum conoides, an anastomosis the branches of which extend into the interior of the larynx. Quite frequently (Streckeisen, always) a transverse branch of the superior thyroid artery is found along the upper margin of the isthmus, while the venæ communicantes are quite constant and rather large. These vessels, however, lie close to the thyroid within the layer of fascia surrounding it, and are not injured if care is taken to stay outside of this membrane. The lobulus pyramidalis or any secondary thyroids are supplied by the superior thyroid artery or by a descending branch of the cricothyroid artery, as emphasized by Kaufmann. Grüber found this latter condition in 7 of 100 autopsies. Below the isthmus of the thyroid gland large veins surround the trachea which collect blood from deeper seated regions and extend downward as two to four trunks in the loose fatty tissue between the trachea and the cervical fascia (plexus thyroideus impar Hyrtl), and finally open into the innominate veins. Normally there are no arterial trunks in the lower section of the trachea in adults. The innominate vein is behind the sternum. In children it is higher up; always above the level of the notch, extending from the left side downward to the right, in front of the trachea. According to Bruns and Trendelenburg, it leaves the trachea about one-quarter to one-half inch above the sternum in a child twelve months old, rarely deeper. In adults this condition is to be considered abnormal. In exceptional cases, however, it may reach as far as the lower margin of the thyroid gland. Of abnormal vessels which may render exposure of the suprasternal section of the trachea difficult there may be mentioned first the arteria thyroidea ima. (Neubauer.) This usually arises from the arch of the aorta, rarely from some secondary branch, and accompanies the lower veins in the free tracheal fat along the median line or a little to one side up to the lower margin of the gland. According to Grüber, this is said to be present in 1 of 10 cases. It does not seem to be of as much practical importance as might be expected from these anatomical data; Trendelenburg did not meet this artery once in 80 tracheotomies, and according to Settegast, it was not seen once in 754 tracheotomies performed in children (Bethanien, Berlin). Neumann did not meet a single abnormal vessel-supply in 764 tracheotomies (Friedrichshain). Fortunately the trachea is traversed horizontally by arterial trunks of abnormal origin so rarely that it will be sufficient simply to mention the possibility. With reference to the individual varieties, information may be found in G. Fischer's extensive article. In the superficial layers there are many subcutaneous veins which can usually be seen in patients suffering from dyspnœa as tense parallel strands shining through the skin. Usually there are two parallel trunks near the middle line in the superficial cervical fascia joined together in the jugular fossa in the arcus venosus juguli, or there is but a single trunk (vena mediani colli).

Inasmuch as most tracheotomies are performed in young children, the anatomical conditions due to the age of the patient, which have not already been mentioned, will next be considered. The peculiar development of the larynx explains why the space between the isthmus and the margin of the sternum in a child two years old may not be any smaller than in an adult (Trendelenburg), while the distance between the cricoid and the margin of the sternum, according to Merkel, is not a centimetre less in a child six years of age than in an adult. Trendelenburg's measurements showed that between the innominate vein and the thyroid gland there was a space of six tracheal rings in spite of the high position of the former. Besides this the distance between the surface of the skin and the lower portion of the trachea is naturally much smaller in children than in adults. On the other hand, the field of operation is encroached upon not infrequently in children by the thymus gland, which often reaches above the sternum and may even be in contact with the thyroid. Hüter divides the available space into five sections, and distinguishes five varieties of tracheotomy as follows:

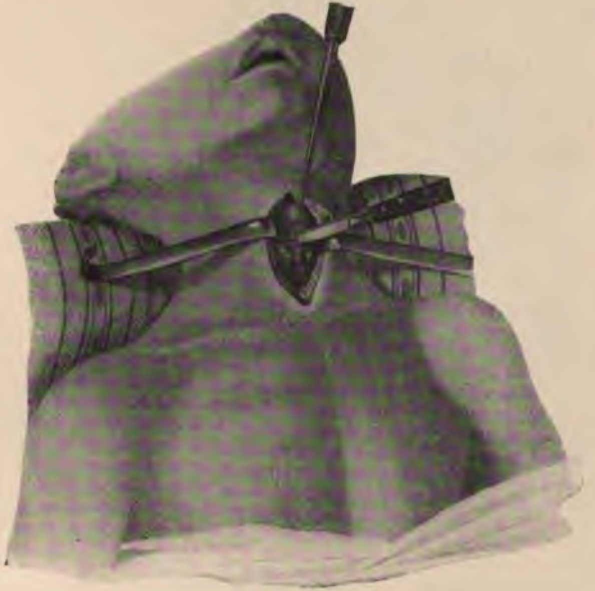
1. Thyrocricotomy. Division of the cricothyroid ligament.

2. Cricotomy. Division of the cricoid cartilage—*i. e.*, cricotracheotomy, if the first or first two tracheal rings are included in the incision.

3. Tracheotomy superior, s. suprathyroidea. Section of the upper tracheal rings above the isthmus of the thyroid gland.

4. Tracheotomy media, s. retrostrumosa. Section of the isthmus of the thyroid.

FIG. 79.



Tracheotomy.

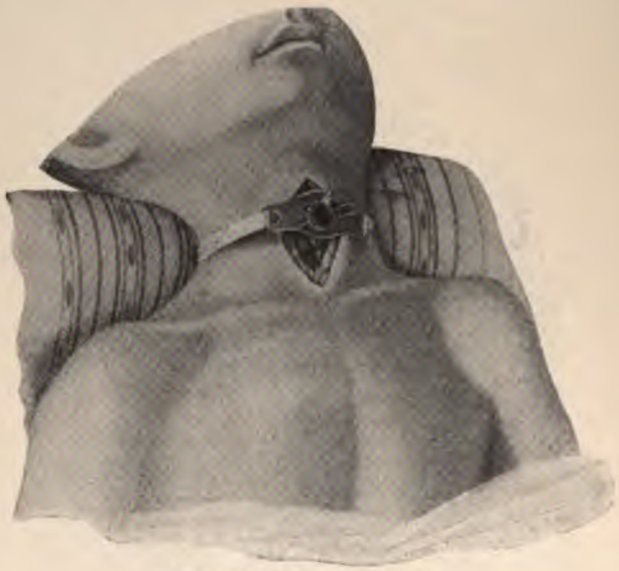
5. Tracheotomy inferior, s. infrathyroidea, in the space between the thyroid gland and the innominate vein.

For practical purposes it will be sufficient to describe the operative technic of two methods—*i. e.*, of tracheotomy above and below the isthmus of the thyroid. Whosoever is familiar with the technic of tracheotomy superior in the restricted sense of the word will be able to undertake division of the cricoid or of the cricothyroid membrane if it should be necessary in any given case. Cricotomy is usually considered to be the technically easiest method.

Technic of Tracheotomy.—The steps of operation in a diphtheritic child, and technical variations arising from other indications, will be described. As far as instruments are concerned, the simpler the better. Complicated accessory appliances that have been advocated from time to time, and which have fallen into well-deserved oblivion will not be considered.

Generally speaking, it is sufficient to have one or two sharp-pointed knives, two retractors to dilate the wound, a blunt hook for the isthmus of the thyroid, two sharp tenacula for the trachea, two pairs of forceps, a hollow sound, Cooper's scissors, some artery-clamps (the author prefers to have at least a dozen of these so as to avoid tying arteries), an elastic catheter, and finally a tube of the requisite size, or, better still, two of varying size. Sometimes it is convenient to have a blunt-pointed bistoury, a sharp tenaculum to fix the larynx, and a blunt hook to depress the pretracheal tissue in performing tracheotomy inferior. With limited assistance the retractors may be supplanted by Bose's self-acting hooks. For the purpose of steadying the trachea, the author prefers a simple tenaculum to that of Bose, because the latter, although convenient in an operation higher up, cannot be used low down, and cannot therefore take the place of the former in the lay-out. Finally, it is well to have a needle-holder with curved needles, because a certain kind of hemorrhage, especially when the thyroid gland is injured, is quickest and most safely stopped by tying in the surrounding tissues. The preparation of the patient, providing his condition permits, is very much as for other operations. If, however, there is no time for this, the skin at least is cleansed with ether. The position

Fig. 80.



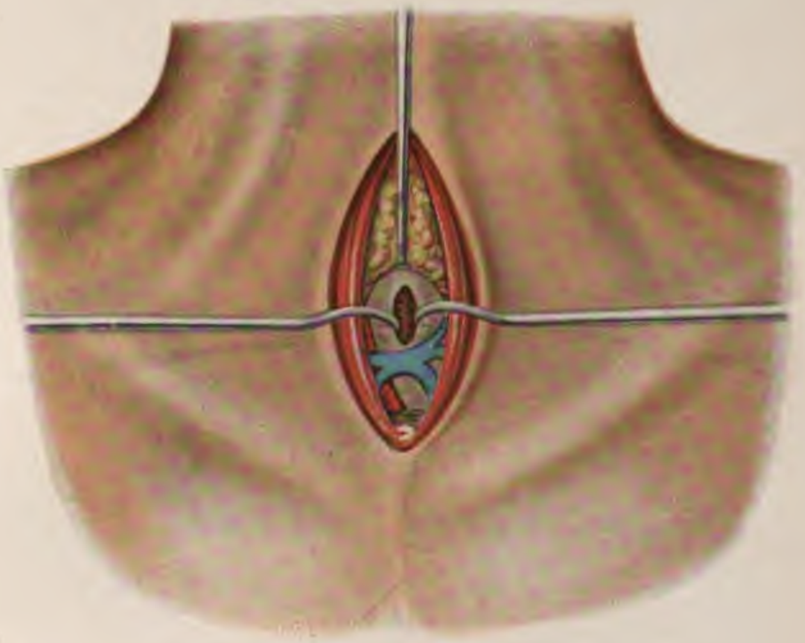
Tracheotomy-tube in position.

of the patient is important. The head is extended over a sandbag placed under the neck. This is possible without increasing the dyspnœa. The body is fastened to the table by a strap going over the thighs and the hands are tied to the table. The methods of securing the patient must not in any case interfere with the respiratory excursion of the thorax. The justification of general anæsthesia in tracheotomy has been much discussed. The favorable experiences in practice have removed to some extent the theoretical objections made to the use of chloroform in children with dyspnœa. As a rule, a few drops of chloroform will be sufficient to produce anæsthesia. The first few moments only are disquieting because the patient struggles against the anæsthetic. The breathing subsequently may become more quiet and freer than before anæsthesia, the violent excursions of the larynx become less, and the congestion in the veins of the neck is less when the struggling and the subjective signs of dyspnœa cease. The gain in rapidity and accuracy of operating is so great that the objection to anæsthesia need not considered. In the stadium asphyxicum the advanced carbon dioxide intoxication renders anæsthetizing unnecessary. In adults anæsthesia may be advantageously supplanted by the local use of a 1 per cent. solution of cocaine or by Schleich's method, provided, of course, that the condition of the stenosis permits of a method requiring somewhat more time.

The operator first palpates the anterior region of the neck, and finds the lower margin of the thyroid or cricoid cartilage. In children the latter can oftentimes be distinctly felt, more so than the soft and less prominent thyroid cartilage. The incision through the skin is made over the lower margin of the cricoid downward in the median line for about 3 or 4 cm. The author agrees with those who recommend that the skin-incision should not be too small, because a sufficient opening renders the operation decidedly less difficult. Especially in a vicinity where goitre is common (the author's experience is taken from such a region), it is almost an absolute necessity to divide the skin down to the jugulum so that upper or lower tracheotomy can be performed according to the condition found. The author has never seen any objection to a long skin-incision. The anterior subcutaneous veins are pushed one side and any transverse communications divided between clamps. Generally speaking, it is best to leave the clamps in place and tie the vessels after the trachea has been exposed or even after opening, when time is short. The snaps hanging down at the side oftentimes replace the retractors.

The line of cleavage between the sternohyoid muscles is sought (linea alba colli) and layer by layer divided, avoiding all hemorrhage. Bose recommends that one should always determine whether the muscles on both sides can be displaced to an equal extent, so as to guard against deviating from the median line. If the operator gets to one side, the muscle of the other side will be adherent. The technic of separating the soft parts varies considerably; whereas some prefer Langenbeck's dissecting method and divide layer by layer between

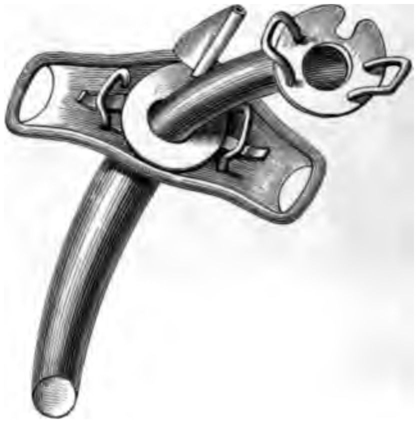
PLATE VIII.



Tracheotomy, Inferior. (Zuckerkandl.)

mechanical irritation of the trachea with a catheter prove ineffective, aspiration should be attempted. The value of this method for removing fluid is generally recognized, but for the removal of deep-seated membranes it is of disputed value. It is a fact that a not insignificant number of physicians have lost their lives in attempts to save children by aspiration. Albert and Stromeyer recommend the use of a syringe so as to lessen this danger as much as possible, and Passavant makes use of a rubber ball. The canula should be introduced only when breathing has become free and quiet. This usually occurs without any trouble provided the incision has been made large enough and the above mentioned hooks have been used. If the opening proves too small, it should be enlarged with a blunt-pointed bistoury, for it is never justifiable to introduce forcibly a canula through a small incision. The tapes attached to the canula are fastened at the back of the neck. After the canula is well placed, the hooks may be removed. The wound is powdered with iodoform or with aristol and packed with iodoform gauze. A pad of gauze split on one side is placed underneath the shield of the canula and a piece of rubber tissue over this, so as to avoid soiling of the dressing by secretion coughed out through the tube.

FIG. 81.



Luer's double canula.

For the purpose of preventing diphtheritic infection of the wound the author has endeavored, following Schimmelbusch's experiments relative to infection of fresh wounds, to guard mechanically and antiseptically the incised tissues before opening the trachea by painting the entire wound with iodoform paste. Even if this be done after the trachea has been fixed with the hooks, the accuracy of the incision is not influenced. The secretion finds all the interstices of the tissue occluded by the paste. The results obtained by this method, even in the anteserum period, render it most valuable. This procedure is, at any rate, less destructive than cauterization with ferric chloride (Bose) or a 10 per cent. solution of zinc chloride.

A judicious selection of the tracheotomy-tube is of importance. The author makes use of the well-known Luer's double canula, made of silver and provided with a shield (Fig. 81), and prefers, for reasons to be mentioned later, one without a fenestrum. In young children metal canulas alone should be used, because they can be made so thin as not to encroach upon the lumen perceptibly. The curve should always correspond to about one-fifth or one-fourth of a circle, because only in this way is it possible to introduce a stiff inner tube. The use of flexible inner tubes (jointed, Durham) is associated with technical disadvantages which are greater than the advantages, especially with the smaller canulas. Gersuny has shown that even a stiff inner tube may be introduced into a canula with a straight end-piece, provided the latter is somewhat funnel-shaped.

The diameter, the length, and the curve are factors upon which depends the value of any canula in a given case. Trousseau has emphasized the necessity of using canulas of large diameter, especially in cases of tracheotomy in diphtheria, because they render the expulsion of membrane more easy. It is best to use the size which can just be easily placed within the trachea. Regarding the length, Passavant, who has made a study of tracheotomy in croup, recommends that the portion situated within the trachea, measured from the lower angle of the incision downward, should always be one and a half times as long as the diameter of the trachea. The length of the external portion depends on the depth of the incision, which, of course, renders longer tubes necessary in tracheotomy inferior than in tracheotomy superior. Secondary swelling of the soft parts may sometimes render a canula which fitted at first too short. A canula that is too short is useless. Provided it is too long, the pad of gauze placed beneath the shield may be made thicker. An attempt has been made to determine the normal size for the various periods of life, based upon measurements taken post mortem by Cook, Weinberg, Passavant, and others. Below is given the somewhat abbreviated table of Passavant's. The measurements given by Cook average about 0.5 mm. less.

Age.	Diameter of trachea.	Diameter of external canula.	Lumen of internal canula.	Length of canula, concave side.		Radius of concave side.
	mm.	mm.	mm.	Short C.	Long C.	mm.
1½–2 years . . .	5– 6	5.5	4	76°	111°	19
2 –4 " . . .	7	6.5	5	81°	101°	21
4 –6 " . . .	8	7.5	6	83°	96°	23
6 –8 " . . .	8	8.5	7	85°	102°	24
8 –12 " . . .	10	9.5	8	82°	103°	25
Adults	12–23	11–13 and larger	9–11 and larger	81°	103°	29

The individual variation in the diameter of the trachea and in the amount of soft tissue is so great that it is always well in any case of tracheotomy to have ready two canulas of different size. The lower opening of the tube should not have a sharp margin. When the stenosis of the trachea is deep seated, the ordinary canula will prove insufficient. One may temporarily make use of a piece of an elastic catheter or of a stomach-tube cut the proper length. König recommends in cases of this sort his spiral canula (pressure-stenosis from goitre). This has the advantage of adapting itself to the curves of the stenosed trachea. This wire tube, however, is not without its disadvantages. (Fig. 82.) The author possesses a specimen which became much stretched during an attempt to change the canula, because the lower end was caught at the seat of stenosis. v. Bruns has recently advocated a simple tube which is free from these objections. A piece of spiral tubing, such as is used to convey gas, is made for this purpose of very thin silver sheeting without interposed rubber. A clamp surrounds this, to which is attached a shield very much like that of Luer's canula. (Fig. 83.) The clamp permits of any position of the shield, so that no matter how long the tube it is not allowed to enter the trachea except to the necessary extent in any given case. The margins of the wire are so rounded that there is as little danger of irritating the trachea as with König's model, and any danger of this sort may be avoided by covering with rubber tissue. The peculiar construction of this tube (Fig. 84) allows of lengthening and shortening and has great lateral mobility, which is an advantage in cases of tight stenosis where the stricture tends to close down tightly on the lower end of the tube.

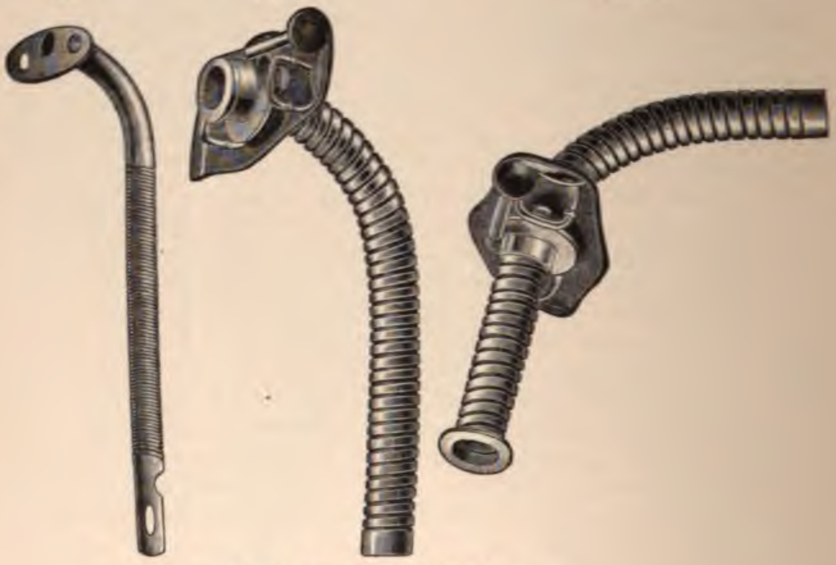


Fig. 82. Fig. 83. Fig. 84.

Fig. 82.—König's spiral canula.
Figs. 83, 84.—Flexible canula of v. Bruns.

Accidents during the operation may be the result of technical errors, which are most common, of course, when the operator becomes confused. Sometimes it is not the surgeon, but the conditions presented by the disease that are responsible. The earlier patients with stenoses are operated upon, the more these dangers during the operation will disappear.

The danger of hemorrhage and how to meet the same have been mentioned.

In urgent cases, when there is no time to check the bleeding with clamps, it is justifiable to attempt to prevent the entrance of blood by compressing the trachea against the canula. The patient should be raised at the same time so as to allow the blood to flow freely from the wound. The author has never been obliged to make use of this method. The hemorrhage from the wound is, generally speaking, slight, providing it does not come from the cricothyroid artery.

Asphyxia may occur during the operation as the final result of prolonged stenosis, or it may arise suddenly, due to complete occlusion of the larynx or as the result of careless use of anæsthetics. This demands rapid ending of the operation and artificial respiration or König's cardiac massage. The operation itself may result in asphyxia on account of too great extension of the head or kinking of the trachea, due to too great traction upon the hooks. As soon as the cause is recognized the indications will be evident.

Separation of the mucous membrane, described by Pitha, is of little practical importance. Provided the trachea has been fixed by means of hooks, as recommended above, the knife may be introduced so accurately that there is little chance of separating the mucous membrane or perforating the posterior wall of the trachea or œsophagus. Plugging by membranes is of greater importance. These are sometimes separated with the knife or pushed together by the canula. In cases of perichondritis the canula has been introduced beneath a mucous membrane elevated by pus. These accidents will be avoided if one is not in too great a hurry to introduce the canula.

The after-treatment of children that have been tracheotomized during diphtheria demands the greatest judgment on the part of the physician and the greatest care and sacrifice on the part of nurses. The fate of a child that has barely been saved from death from suffocation will depend to a large degree upon these factors as well as upon a technically correct operation. The breathing of the child should be watched continually day and night. Whenever it does not seem to be quite free, the cause must be found and removed. It is of primary importance to avoid plugging of the canula. This is produced not so much by detached portions of membrane as by the abundaut secretion, which dries to tough, glue-like crusts due to contact with the external air. This condition especially demands the use of a double canula in cases of tracheotomy during diphtheria. Any accumulation of mucus must be removed immediately by taking out and thoroughly cleaning the inner tube. This may be done best by means of a wet piece of gauze, a corner of which is pushed through the tube with a bent probe. Even when the inner tube is kept clean plugging may occur, because a diaphragm-like crust may develop across the opening of the outer tube just where the inner tube stops. The lumen of this becomes smaller and smaller. This incrustation, due to secretion, is observed in other conditions besides diphtheria. When the breathing is not free, even after removal of the inner canula, the outer canula must also be removed.

Moist air is a valuable means of preventing drying of the secretion. A steam spray is placed about three to five feet from the bed of the child, and the current directed toward the region of the neck. The bed should be protected by waterproof material. Various aqueous solutions (salt, glycerin, lime) have been recommended for vaporizing, the object being to have a direct solvent action upon the secretions of the mucous membrane. The chief effect, however, is probably due to the water. Steam heating may be made use of by fixing a stop-cock so that the steam is allowed to enter the room or by connecting a spray apparatus with a radiator, as recommended by Baginsky. The author has always been satisfied with the results of the steam spray, and has never felt obliged to use the various medicinal agents in solution, as frequently recommended.

Whenever the obstruction to respiration, such as mucous crusts or a tab of membrane, is situated below the canula, an attempt should be made to remove the obstruction by means of a catheter or Roser's wire rings. Some authors believe, relying upon Hüter as an authority, that even in descending croup energetic use of aspiration may result in saving life. The author shares König's opinion that the beneficial results are as a rule only temporary. Perhaps the use of serum renders the prognosis in these desperate cases more favorable by limiting the new formation of membranes. The author does not believe it justifiable in any case to irritate without necessity an already inflamed trachea with an aspirating catheter or any other instrument.

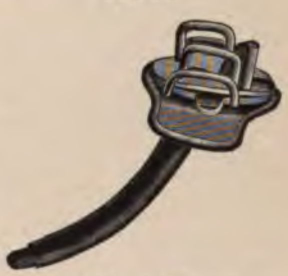
It is best to avoid changing the canula during the first few days after operation, and wait until a distinct tract has been formed in the wound. If unavoidable for some of the reasons already given, or because the canula does not seem to fit, it should be done with certain precautions. The position of the child should be as at the time of the operation, and the edges of the trachea should be held with hooks. Provided intratracheal interference is not necessary, it is well to introduce the second canula without further delay. The recommendation made by various authors to use a suitable elastic catheter as a guide and pass the canula over this, is excellent. In the later stages, when a firm granulating sinus is present, precautions of this sort may be unnecessary. One should avoid removing the canula for any length of time on account of the tendency of the tracheal wall to contract. Even a few moments may be sufficient to render difficult introduction of the size previously removed. Final removal of the canula (decanulement) should be performed when a free passage of air through the larynx is established. Owing to the use of serum, it is at present possible to attempt removal of a canula usually on the third day.

Trousseau claims that from the sixth to the tenth day is the average period. Kappeler was able to remove the canula within six days in 70 of 108 cases, and 86 times within one week. Fischer introduced the convalescent tube in 50 per cent. of 1000 tracheotomies during the first week, and was able to leave the tube out within the next three days in 42 per cent. of the cases. In 51 per cent. of his cases he was able to remove the tube during the first week. In the Children's Hospital at Basle, according to Feer, the canula was removed between the fifth and tenth day. Köhl has made an extensive collection of statistics from the older literature bearing upon the removal of the canula. The length of time that it is necessary to wear a tube has been shortened several days by the serum treatment (Krönlein removed the tube usually on the third or fifth day).

The canula can be removed in various ways. First of all (about the third day), one should endeavor to find out by stopping up the end of the canula whether air can pass through the larynx. When this is the case, the tube may be removed. If the breathing is free when the wound is held closed, an attempt may be made simply to remove the canula and watch the child the entire day. A thin canula, an after-treatment tube, should always be ready, so that it can be introduced at any moment.

Canulas with lateral openings (silver, hard rubber) are recommended during convalescence, because the inner tube can be removed and the opening of the outer one stopped with a cork. The tube is permanently removed when the child can sleep quietly for an entire night with a plugged canula. In v. Bruns' clinic a thin convalescent tube (4 mm. in diameter) (Fig. 85) has been used for many years. The inner tube is not pervious and reaches somewhat beyond the outer one. This allows the air to pass without difficulty, and should sudden interference with respiration take place, it acts as a safety-valve because the nurse need only to remove the inner tube.

FIG. 85.



Canula of convalescence.

After removal of the canula the wound usually closes within a few days. While the canula is in place, it is well to smear the surroundings with lanolin or zinc salve, so as to prevent eczema and erosion of the skin by secretions. The progress of the after-treatment above described undergoes certain modification, of course, dependent on the indications for tracheotomy. Generally speaking, one may safely say that the after-treatment of tracheotomy as such is much more simple than when done because of diphtheria; for instance, if a foreign body has been removed or a preliminary tracheotomy performed, it may at times be justifiable not to use any tube at all. In cases of this sort it has even been recommended to suture the trachea immediately as well as the external wound and drainage. The author has personally done this, and has been well satisfied with the results; whereas in diphtheria suturing is to be condemned on principle. The more or less cumbersome methods of moistening the air can be done away with, provided there is no diphtheria. A small moist gauze pad in front of the canula will, as a rule, give sufficient protection to the mucous membrane and avoid irritation from direct contact with the air and dust.

Disastrous accidents during convalescence and the secondary results of tracheotomy will be considered only in relation to their connection with the operation as a cause, or because they have given rise to some disturbance in the local process of healing.

Emphysema of the connective tissue may develop, because the canula has slipped out of the trachea. This occurs most often in tracheotomy inferior, when the secondary swelling renders the canula too short or when the latter was rather short at first. It is evident that even a suitable canula if improperly fastened may become dislodged by an attack of coughing. Careless changing of the canula, accidental removal of the external canula by nurses, or removal of the canula by the patients, should be mentioned as causes of emphysema. An accident of this sort may lead to death from suffocation, provided immediate aid is not obtained, even without the development of emphysema.

The author recalls a case in which a very extensive emphysema was produced, extending over the head, the neck, and the upper portion of the chest, within a few moments after a canula had been displaced by a violent attack of coughing. The child was saved by a very slight margin, for reintroduction of the tube was extremely difficult. Neumann found that emphysema developed 9 times in 764 cases; 4 from the lung and 5 from the wound. When a firm granulating sinus has formed, there need be little fear of emphysema.

Diphtheria of the wound and its results have been considered.

There may be extensive necrosis of cartilage even when there is no diphtheria of the wound, due to suppurating processes in the pretracheal connective tissue, followed by perichondritis. According to v. Bergmann's experience, the cricoid cartilage when divided seems especially prone to partial necrosis. Pressure-ulcers produced by the canula are not infrequent, and may be of grave significance. Roger observed pressure-ulcers 13 times in 63 operations—*i. e.*, 20 per cent.; Jenny, 13 times in 82 cases—*i. e.*, 16 per cent.; Lahr, 14 times in 189 autopsies performed in the Pathological Institute at Giessen—7.4 per cent.; and Engelmann, in Halle, 25 times in 104 autopsies. The usual seat of pressure-ulcers corresponds to the place where the lower margin of the canula presses against the anterior wall of the trachea. Ulcers of the posterior wall are more infrequent, and are produced by pressure of the convexity of the tube. They seem to be more common when canulas with lateral openings are used, especially when the window reaches sufficiently far back, as explained by Köhl, to allow the inflamed and loosened mucous membrane to enter. Faulty construction of canulas, and, above all, a disproportion between the curve of the canula or its length and the anatomical conditions of the trachea and soft parts, as shown conclusively by Trendelenburg, is very apt to result in ulcers. The appearance of an ulcer is made manifest clinically by the occurrence of pain in the suprasternal notch, fever, and expectoration of mucus streaked with blood. The lower end of the canula is blood-stained, or, provided the ulcer has been present for some time, there may be a black discoloration due to silver sulphide. Marked swelling of the margins of the ulcer below the canula may cause obstruction to respiration. The fatal secondary conditions will be considered later.

If the above-mentioned symptoms indicate to the surgeon that he has erred, it will usually be sufficient to use a somewhat shorter tube; if this does not render breathing sufficiently free, an attempt should be made to use a somewhat longer tube with a straight terminal portion. (Durham, Gersuny.) Sometimes it is well to try to pass the seat of obstruction with a flexible canula, or in an emergency employ a soft-rubber tube or a piece of catheter. These remarks apply to the rare cases of deep-seated diphtheritic ulcerations of the trachea. (Passavant.)

Hemorrhage may occur quite early after operation. König reports a case in which a child succumbed to hemorrhage due to division of a transverse vein eighteen hours after operation; and Kermauner mentions a similar case in which death occurred on the fourth day. During convalescence it is not uncommon to have blood mixed with the expectoration (Jenny, 25 per cent. of all cases from the third day on). This is due either to ulcers or in some way to separation of diphtheritic membranes in the trachea. Hemorrhage may be caused by injury to granulations while changing the canula or too energetic methods of aspiration. As a rule, there is no direct danger associated with these slight hemorrhages. Sometimes, however, they are the forerunners of severe or even fatal bleeding, due to opening of some larger vessels, which is not so infrequent an accident as is commonly believed.

Krenzer has recently collected 22 cases of death due to hemorrhage after tracheotomy, 5 of which were in the clinic at Bonn; 16 other cases were found in literature, reported by Guersant, Wood, Bruns, Wilks, Zimmerlin (3 cases), Lucas (3 cases), Maylard, Jenny, Lahr, Hecker, and Kermauner. Two additional cases have been reported in v. Bruns' clinic. Of 36 cases in which the source of hemorrhage was given, 28 were traced to the innominate vein, 2 to the right carotid, and 1 each to the superior thyroid, the left innominate, the right jugular, and the left jugular. The vast majority of fatal hemorrhages were in cases of tracheotomy inferior. The innominate vein has been opened only twice in tracheotomy superior (Krenzer, Lahr), and once in cricotracheotomy (Verneuil). Hemorrhage from the superior thyroid vessels is, of course, associated with tracheotomy superior. It is rare to have hemorrhage from ulcers on the posterior tracheal wall. As far as the time is concerned, fatal hemorrhages apart from primary hemorrhages have been observed from the third day to months after operation. Several times they occurred after the canula had been permanently removed.

1. Erosion of vessels by diphtheritic or suppurative processes. Exceptionally perforation has been observed without apparent infection of the wound. This is especially to be feared when the artery is in the granulating region of the wound, or exposed at the time of operation, or has been injured in some way.

2. Partial necrosis of the wall produced by pressure. This condition, according to the observations at hand, is still more common, although, of course, both conditions may be present at the same time. Ordinarily there develops a direct communication between the trachea and the lumen of the vessel over the area corresponding to the lower end of the tube, which in tracheotomy inferior often presses against the anterior wall at the level of the innominate vein. Perforations of the innominate veins for this reason are seated along its convexity, and usually in the posterior wall.

Whenever one of the larger trunks is opened, death usually takes place within a few moments, whereas hemorrhage from the small vessels, especially from the parenchyma of the thyroid gland, as observed by various authors, especially in tracheotomy superior, may be checked by styptic packing (ferric chloride, cotton). The treatment to be pursued is indicated in the above description. One is powerless in case of hemorrhage from the large vessels, so that the necessity of observing prophylactic measures becomes so much the more urgent. An effort must be made to avoid diphtheria of the wound, ulcers, etc., and to change the canula immediately should symptoms arise which lead one to suspect the development of an ulcer.

Although fatal hemorrhages are so rare that many surgeons who have performed a large number of tracheotomies have not had any personal experience, the same does not apply to a series of local changes which have in common that they retard the removal of the canula, or may render this impossible for the time. This may be the case even after recovery from the disease which rendered the operation necessary (diphtheria as a rule). The conditions that render removal of the canula difficult have been studied by Köhl. He mentions the following causes, based upon his personal observation and careful consideration of the literature: 1, diphtheria with protracted course; 2, recurrent diphtheria; 3, chorditis inferior; 4, the formation of granuloma; 5, kinks in the trachea, changes in shape in the larynx and trachea, caused by interference and the canula; 6, a relaxed condition of the anterior tracheal wall; 7, stenosis from compression; 8, stenoses from scars; 9, paralysis of the larynx; 10, habit-paresis; 11, fear of removing the canula; and 12, spasm of the glottis. Only those processes which are important on account of their frequent occurrence will be considered.

Of the causes that render removal of the canula impossible, stenosis from granulation-tissue is by far the most common and of the greatest interest. Numerous cases are reported in literature (Köhl and Schneider, the latter 164 cases), although the number is small compared with the number of tracheotomies. The frequency of granuloma varies considerably in the different statistics on tracheotomy (of 650 tracheotomies in v. Bergmann's clinic, there was not a single case due to granuloma, according to v. Bramann). Krönlein reported 1 case in 504 tracheotomies; whereas Feer reports 22 cases in 333 tracheotomies at the Children's Hospital in Basle; and Köhl reports 20 cases of stenosis due to granulations which occurred between 1875 and 1884 after tracheotomy at the Children's Hospital in Zürich.

Overgrowth of granulations takes place along the tracheal incision, and usually in the region of the upper angle. It is much more uncommon at the inferior angle or around the entire circumference of the wound. Granulations situated at some distance from the line of incision are found only in the larynx. They are sometimes due to an ulcer opposite the lower end—*i. e.*, the convexity of the canula. The granulations have, as a rule, a broad base at first. After a variable time they become more and more polypoid by progressive diminution in the size of the peduncle. This condition was at first supposed by Koch to be due to the suction of aspiration.

Granulations have been observed as early as the fifth day. As a rule, the impossibility of removing the canula permanently discloses these granulation polyps. The cases are very unusual in which days or weeks may have passed after removal of a canula, even when the external wound has closed, before respiration is interfered with. These are so-called scar-granulomata. The latter were probably always present to a slight degree at the time the tube was removed, but so small that they produced no symptoms. They slowly develop and become swollen, due to contraction of scar-tissue around their base (Trendelenburg) and because of the negative inspiratory pressure.

Köhl, with Carrié, Völker, and Passavant, makes so-called dead spaces in the angle of the wound responsible where the pressure is slight. The development of these spaces is favored by incisions in the trachea that are too large. Pauly claims that the irritation of a canula left in place too long is responsible. Canulas with openings have been condemned by Trousseau as useless and dangerous. It is reasonable to suppose that a window which extends around too far in front will irritate the margins of the wound, whereas one that extends too far backward will irritate the posterior wall. A tuft of granulation-tissue has been repeatedly observed to grow into the opening. (Trendelenburg.) Many authors have brought the method of operation in relation to the development of granuloma by claiming that the tendency to the formation of such growths is increased the nearer the tracheotomy-wound is to the vocal cords. The physiological constriction of the trachea above the cricoid cartilage and the loose attachment of the laryngeal mucous membrane have been considered to favor these granulomata. It is a fact that the vast majority of cases of stenosis due to granulation-tissue are observed where the incision was made above the isthmus of the thyroid gland, although they have also been observed in tracheotomy inferior.

Of the cases reported by Köhl, cricotracheotomy was performed 17 times; tracheotomy superior, 26 times; and tracheotomy inferior, 10 times. Of the 22 cases of granuloma reported by Feer, cricotracheotomy was performed in all except 2 in which the growth was due to pressure from the lower end of the canula. Five cases of stenosis mentioned by Jenny occurred in 54 cases of tracheotomy superior that recovered (3 cricotracheotomies), whereas in 54 cases of tracheotomy inferior recovery was undisturbed. The fact that tracheotomy inferior is a much rarer operation does not explain why the statistics of tracheotomy inferior show so few cases of stenosis. The results obtained at the hospital in Friedrichshain are interesting in this connection. Of 282 cases of tracheotomy inferior, 1 per cent. were discharged with a canula; and of 153 patients with tracheotomy superior, 9 per cent. wore a tube when discharged.

Dyspnœa is the chief symptom of granuloma. This may develop either immediately after removal of the tube or in the course of several hours, when the fistula begins to close and the granulations swell in the way described. The dyspnœa may increase suddenly, due to excitement or physical exertion. This is probably owing to increased blood-pressure and respiration. The condition may be intensified by lying on the back, because the polyp in this position may touch the posterior wall or fall against the glottis. Acute suffocation has been repeatedly observed in connection with removing the canula, either immediately or after the wound had healed.

The diagnosis is established by laryngoscopic examination or by grasping the growth through the dilated fistula by means of special instruments—forceps and wire loops. In this way the seat of origin can frequently be determined. According to Trendelenburg, the canula may be made use of as a diagnostic aid, especially in cases in which dyspnœa occurs immediately. Granulomata at the upper angle of the wound render breathing through a plugged fenestrated canula impossible; sometimes they may be grasped through this lateral opening. Granulomata in the lower end of the wound do not interfere with breathing so long as they are pressed against the wall by the canula. Only when the tube is sufficiently removed to liberate them does dyspnœa occur.

The prognosis is always doubtful on account of the great tendency that granulomata have to recur and because death from suffocation may occur even after years. This makes the patient or the patient's parents finally despair of operations and renders permanent use of a canula necessary. On the other hand, spontaneous cures have been observed after tearing off or shrinking up of the peduncle.

The treatment is directed chiefly toward preventing stenosis. It is recommended as a prophylactic measure, depending upon the etiology, to remove the canula as early as possible, at a time when there is no abundance of granulation-tissue in the wound and before the tracheal cartilage has not lost its elasticity. The incision should be of proper length, fenestrated canulas avoided, and the upper section of the trachea, especially the cricotrachea, operated upon as little as possible. The statistics show that all of these suggestions do not give a guarantee in a given case.

The treatment has to remove the granulations and then to prevent their recurrence. The former is usually easy, whereas the second is difficult. In the majority of cases the granulations may be removed through the fistula. This is best done with a sharp spoon having a flexible handle, or with a small double curette, as recommended by Killian. It is advisable to operate with the head low. If necessary, the fistula must be enlarged a little upward. When the light is insufficient, a small electric bulb, such as is made use of in the mouth and pharynx, may be of aid. A simple head-mirror may be sufficient in an emergency.

In a case in which the wound had closed Böcker was able to remove the granulations through the mouth by the aid of a silver catheter with two windows on the concave side. It is much easier and just as effective to make use of the Voltolini sponge, as recommended by P. v. Bruns. This method renders tracheotomy unnecessary in cases of scar-granuloma, but is, of course, only to be made use of after preparations have been made for tracheotomy.

The recurrence of granulations should be prevented if possible by cauterizing the seat of origin with zinc chloride, chromic acid, or silver nitrate, etc., or with the thermocautery or galvanocautery.

Presuming that the irritation from the canula favors recurrence, Köhl has advised to shorten (three days) as much as possible the time that this is allowed to remain in place. It cannot be removed immediately except in rare cases. Körte made use of Dupuis' T-canula with success. This exerts even pressure on the entire base of the granulation-tissue. He calls attention to several disadvantages, such as the difficulty of removal and introduction, which is at times only possible with the aid of a blunt-pointed bistoury (danger of asphyxia from plugging of the lumen). Passavant tried to overcome the difficulty of introduction by having this canula in three parts. However, the disadvantages of Dupuis' instrument and the irritation of the reintroduced canula have been overcome successfully by Killian's modification of O'Dwyer's intubation, which constitutes a marked advance in the treatment of granulation stenosis and other conditions in which removal of the canula is delayed.

The old scar is oftentimes chosen as the seat for the second tracheotomy. The author cannot agree to this without restriction. Provided the opening is made lower down, this would have the advantage at least that the seat of the new growth, already disposed to the formation of granulation-tissue, is not subjected to irritation from a canula. Even if the surgeon is obliged to make use of the seat of first operation, after the suggestion of Hüter, for the purpose of removing growths, the wound can be closed rapidly, which, of course, would augment the chances of a permanent cure.

Compared with stenosis from granulation-tissue, other organic constrictions of the trachea following tracheotomy are much more infrequent. A kinking of the tracheal wall has been observed to take place in several ways. Köhl distinguishes three varieties:

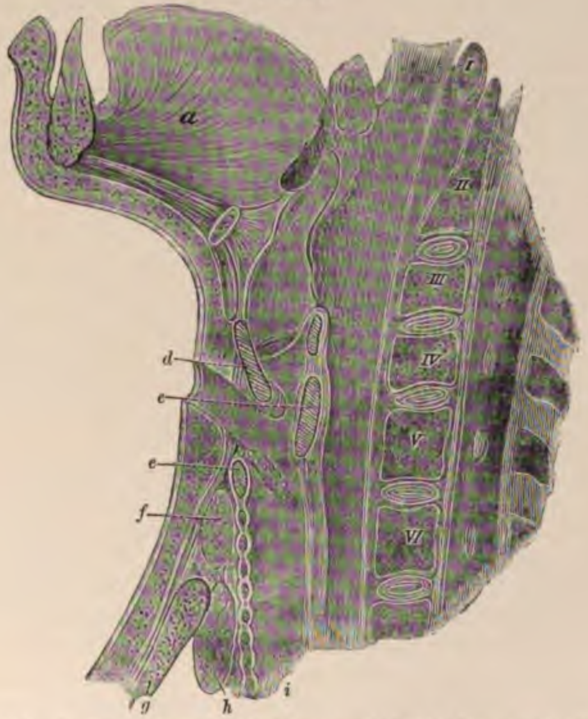
1. Bulging of the posterior wall. This occurs as an elongated swelling into the lumen of the tube, according to Carrié, particularly when the posterior portion of the wall that is free from cartilage is very broad. It is due to approximation of the posterior ends of the cartilage secondarily to the spreading of the anterior portion. A transverse fold in the posterior wall is favored, according to Passavant, by a canula that is too thick and with too shallow a curve. This pulls the lower section of the trachea forward. T-canulas, the arms of which form an angle opening posteriorly, and leave a space between upon which there is no pressure, may also give rise to a transverse fold. These folds become fixed by cicatrization.

2. Inversion of the tracheal margin. This condition is usually found when the incision has been made too small and the canula has been forcibly introduced. König, who has called especial attention to this error in technic, describes this inversion as forming a roof over the upper surface of the canula. A septum, reaching into the trachea from before backward, develops. He advises to lengthen the incision upward for the purpose of removing this obstruction. When the canula is pushed upward, especially if the ligamentum conicum has been cut and the tube presses against the thyroid cartilage, this inversion of the upper margin seems to be favored. (Fig. 86.) Köhl reports an interesting case illustrating the effect of pressure from below upon the canula of Wyss, in which an enlarged isthmus of the thyroid gland which had been separated after Bose's method, exerted sufficient pressure to force the first tracheal ring, which had not been cut, into the cricoid cartilage.

3. Overlapping of the margins of the tracheal wound may give rise to very extensive and increasing stenosis due to progressive cicatrization, especially if the incision was not made in the median line and was very extensive.

Relaxation of the anterior tracheal wall takes place when an extensive loss of cartilage, due to necrosis, is replaced by connective tissue. Sometimes there may be no necrosis, especially if the incision has been very long, but the softening of cartilage after diphtheria, according to Bose, analogous to the so-called tracheomalacia, occurring in some cases of goitre, although claimed to be present by some authors, has not been proved beyond question in these conditions. After removal of the canula the diminished inspiratory pressure on the inside allows the soft scar-tissue to be sucked in toward the posterior wall and gives rise to valve-like occlusion of the tube. In uncomplicated cases of this type of stenosis, according to Passavant, the relaxed wall may be pulled outward by means of a fine tenaculum and the air-passage freed even when the fistula has closed. When this experiment is successful, a diagnosis is definitely established. Stenosis from scar-tissue (next to granulation stenosis the most common) may be present after more or less extensive necrosis of cartilage. Complete cicatricial union between the thyroid and cricoid cartilage has also been reported. (Neukomm, Jenny, Feer.) This condition may also be produced by the healing of ulcers, and is sometimes secondary to operative maltreatment of the trachea, for instance, too energetic cauterization of granulation.

FIG. 86.



Stenosis after tracheotomy, caused by displacement of the thyroid cartilage backward, and granulations in the lower portion of the wound: *d*, thyroid cartilage; *e*, cricoid cartilage; *f*, thyroid gland; *g*, sternum; *h*, thymus; *i*, trachea. (Köhl.)

Aside from extensive lesions giving rise to cicatricial constriction of the laryngotracheal tube throughout its entire length, certain positions seem to be favored by scar stenosis. The region of the incision, and especially toward the upper end of the same, is most frequently affected. Next, the area corresponding to the lower end of the tube, and finally the posterior wall. It has been explained how subglottic cicatricial stenosis may be due to diphtheritic ulcers, so that tracheotomy cannot always be held responsible for this variety.

It has been emphasized as a differential diagnostic point that the sudden attacks of suffocation (swelling of the granulation) occurring with a gradually increasing dyspnœa and observed in cases of granulation stenosis, are absent in the diphtheritic conditions. If present, these attacks occur in the later stages when the amount of occlusion has become very great. Practically the conditions may be very complicated, so that the various types of stenosis may be present in the same case.

Of the nervous causes which delay removal of a canula, only habit-paresis will be mentioned, which may be considered a direct result of tracheotomy or prolonged use of a canula. Violent dyspnœa accompanies any attempt to remove the canula, and necessitates reintroduction of the tube. If it is possible to quiet the child, the canula may be removed while awake, whereas during sleep respiration becomes worse. Gerhardt assumes that when the necessity of keeping the glottis open is obviated, unconscious use of the abductors of the glottis during inhalation no longer occurs, and that especial attention has to be given to breathing before this happens. Other authorities believe (Michael, Passavant) that the condition is not due so much to disturbance of innervation as to weakness of the muscles.

It has been recommended for therapeutic purposes to occlude partially and finally completely the external opening of a fenestrated canula. The author has obtained the same results by using progressively smaller canulas until the above-mentioned convalescent tube can be put in place. This part of the treatment may consume several weeks.

If tracheotomy has been performed early in life, and it has been necessary to wear a canula for a considerable time, the larynx and trachea are oftentimes more or less undeveloped.

Many of the late results (tendency to catarrh, paralysis of the vocal cords, etc.) are not necessarily due to the operation so much as to after-effects of diphtheria itself. All authors who have had an opportunity to examine some time afterward patients who have had tracheotomy performed, agree that in a great many cases there are during the early weeks cough, hoarseness, and dyspnœa, especially at night, symptoms that have a tendency to disappear spontaneously. These signs are in part the result of changes in the voice due to interference with the motility, owing to cicatricial processes in the lower section of the larynx, and partly the result of permanent dyspnœa of varying intensity. Operations high up, especially cricotracheotomy, are much more often associated with these after-effects.

According to Neukomm, who examined very carefully the tracheotomies performed at the hospital in Zurich, 1 child died from suffocation due to stenosis from granulation-tissue out of 81 cases discharged well. Another died of a recurrence of the croup, and not as a result of the operation. Eight others—*i. e.*, 10 per cent.—showed after-effects traceable to the operation itself (2 with hoarseness, 3 with cough, due to irritability of the scar; 3 with dyspnœa on exertion, due to the aspiration of a relaxed scar). Jenny reports 1 fatal case of stenosis from granulation-tissue out of 90 cases discharged well. Five others died of incidental diseases. Permanent dyspnœa was reported in 2 cases, disturbances of the voice in 6 cases, but marked hoarseness in only 1 case. Of 136 cases discharged well from the Children's Hospital in Basle Feer reports that 3 died from cicatricial stenosis, and 8 from incidental diseases. Of 91 cases discharged well the subsequent history of which could be ascertained, functional disturbances were present in 10—*i. e.*, 11 per cent.; the breathing and the voice were affected 5 times each. This condition followed cricotracheotomy 5 times and cricotomy with section of the ligamentum conicum 5 times, and once after tracheotomy superior. It should be mentioned that after section of the cricoid cartilage there is almost always some change in shape, so that an angular depression is present which affects the lumen, instead of the anterior rounded shape. This condition gave rise to symptoms of stenosis 3 times in Feer's cases, and in 1 case reported by Ranke tracheotomy became necessary.

Here will be mentioned a few modifications of the operative technic which are supposed to take the place of the dissecting methods above described, but make special instruments necessary.

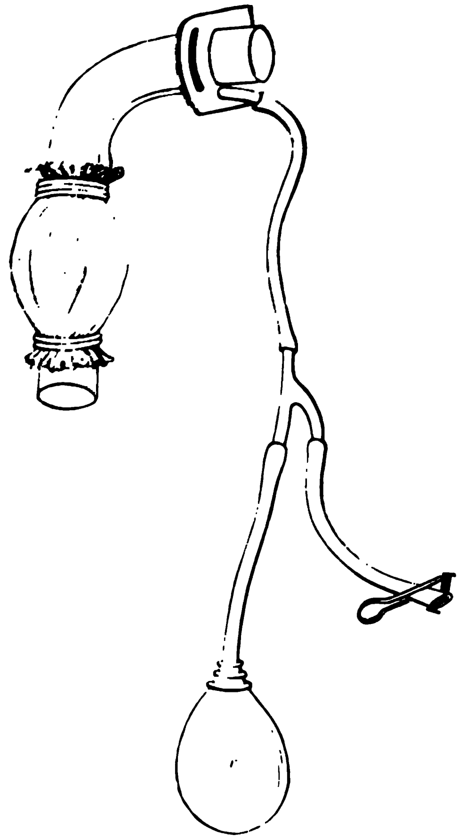
Tracheotomy with one cut, as recommended by St. Germain, is performed by having the operator steady the larynx with one hand and cut through the ligamentum conoidum, the cricoid cartilage, and the adjoining tracheal rings, and immediately introduce the canula with the aid of the dilator. Lubet-Barbon and Lejars have recently recommended a method very similar to the above, which was made use of in 1867 by Bourdillat. The first incision includes the soft parts down to the trachea; the second divides the trachea, while the forefinger of the left hand of the operator, which steadies the larynx, is immediately placed in the opening until the canula can be introduced. Without doubt there are cases in which there is no time for dissection, and it will be safest to enter the knife quickly through the ligamentum conoides. In emergencies a pocket-knife or a pointed pair of scissors may be made use of. A section of tubing or a piece of lead hammered flat and rolled into a tube will give sufficient room for breathing until a canula can be obtained. Although tracheotomy in one incision is justifiable in emergencies, still, in the author's opinion, it is not well to make use of this method generally.

Galvanocaustic tracheotomy, as performed by v. Bruns in 1867, has been abandoned even by this author after a few experiments, because it does not make the operation less bloody, as was expected. On the contrary, the hemorrhage is more difficult to control than with the ordinary method, and the danger of secondary hemorrhage is much greater. Even the cases published later, which were performed chiefly in France, do not influence the opinion expressed by P. v. Bruns in 1872 regarding this method. The same applies, of course, to the use of the cautery. Only when tracheotomy is to be performed through a malignant goitre, where it is impossible to dissect one's way and stop the hemorrhage as in normal tissues, is it justifiable to use the thermocautery.

PACKING OF THE TRACHEA.—This is done for the purpose of avoiding aspiration of blood in operations upon the upper air-passages.

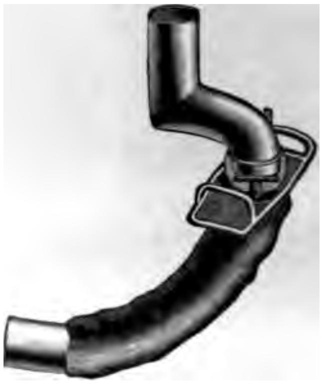
The method of occluding an entrance to the larynx first used by Nussbaum has since been made use of generally, but is adapted, of course, only to certain cases. The upper portion of the trachea has sometimes been packed with gauze through the tracheotomy-wound. (Czerny.) Trendelenburg combined the packing with the tracheotomy-tube. (Fig. 87.) This apparatus consists of a simple canula, the tracheal portion of which is surrounded with a rubber condom. A small tube connected with a bulb passes along the convexity of the tracheal canula and opens into the interior of the rubber sac. The rubber condom can be blown up by means of this bulb. A second bulb is attached externally by means of a key-joint, and the tension in the latter indicates the condition of the condom. Provided that this second bulb is to indicate correctly the condition of the first rubber in the trachea, it must be of the same thickness, and for this reason it is well to cut off the tip of a condom for the bulb and use the remaining portion around the canula. The anaesthetic is given either by placing the mask immediately over the canula or with Trendelenburg's tube and funnel, which does not occupy space in the field of operation and prevents blood from trickling into the canula. Several appliances have been recommended to take the place of Trendelenburg's tampon canula. Mention

FIG. 87.



Trendelenburg's canula with Rosenbach's control-bulb.

FIG. 88.



Canula with compressed sponge. (Hahn.)

only will be made of Hahn's compressed sponge canula (Fig. 88) and Kocher's umbrella canula. In the latter contrivance a flat sponge is tied around the lower end of the canula, so that it stands off from the tube like a funnel. This arrangement offers so much resistance to the tube slipping out of the trachea that it is not necessary to make use of any other method of fixation. Rosa obtains the same result by simply winding ordinary iodoform gauze around the canula. Van Stockum has attached a tampon balloon to O'Dwyer's intubation-tube. With a tampon-tube correctly placed, no air should enter the trachea when the canula is closed. Trendelenburg warns against blowing up the tampon too much, because the rubber may push down over the end of the tube and close it. Complaint has been made that these tampons are not reliable, because the air gradually escapes from the balloon, which may lead to serious results if it is not noticed. Glycerin or water has been recommended for filling the rubber, so as to avoid this condition. However, the value of the external balloon as a control is lost in this case on account of the weight of the fluid itself. This danger may be avoided if the apparatus is tested shortly before applying and a fresh rubber used. When sponge canulas are used, it is, to say the least, not any easier to test the degree of occlusion. In individual cases it has been necessary to abandon the tracheal tampon because the trachea was unduly irritated.

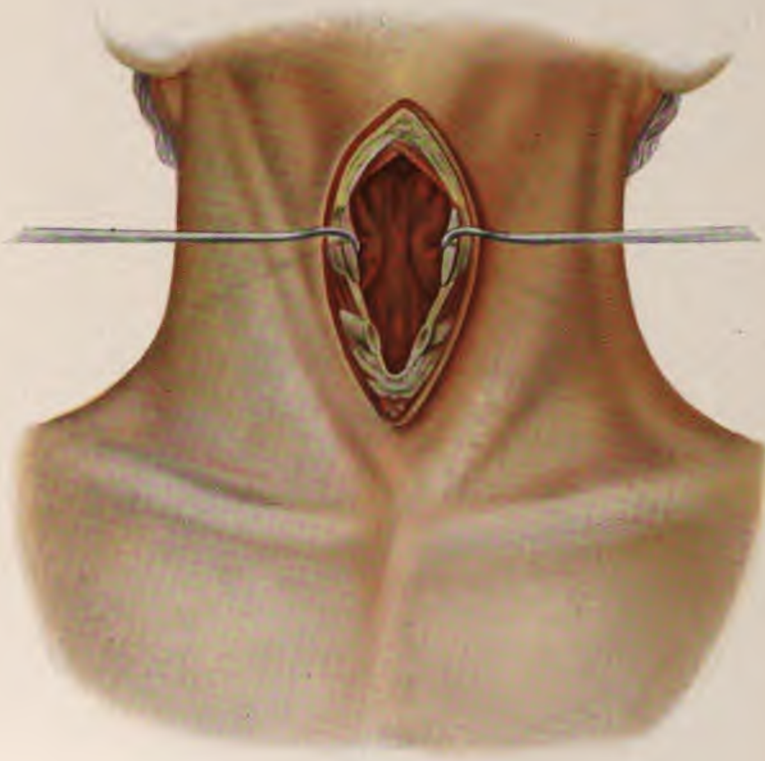
Of late years the use of tracheal tampons in operations upon the upper air-passages has undergone a certain limitation on account of local cocaine anæsthesia. This obviates general anæsthesia, so that the physiological protection lower down in the trachea is preserved during the operation. This matter will be considered more in detail later.

Discussion as to which operation is indicated has been intentionally deferred, because the author believes that a correct opinion can be formed only when all conditions are taken into consideration, especially the after-effects of tracheotomy. Only those cases will be considered in which the nature of the disease does not of necessity indicate the seat of operation, as in diphtheria, for instance. The author condemns as a matter of principle, with v. Bergmann, Angerer, Feer, and others, thyrocricotomy, cricotomy, and cricotracheotomy, and considers that these operations are justifiable only in emergencies, not only because the canula must often be placed through portions of the mucous membrane that are severely diseased in the region of the cricoid, but also because the cricoid itself may be ossified, and because the functional after-effects, as has been seen, are apt to be out of all proportion disastrous in operations in this region. Tracheotomy retrostrumosa is also to be avoided if possible, because of the danger of secondary hemorrhage from the ends of the isthmus ligated *en masse*. It is much more difficult to decide between tracheotomy superior and inferior. When there is no goitre, the superior operation, especially if Bose's modification is made use of, is by far the easier and less severe operation. An enlarged isthmus of the thyroid gland, especially in children, may reverse this decision. As regards the after-effects, it has been claimed that tracheotomy superior delays the time at which the canula can be removed and interferes with the voice and breathing much more often. According to Neumann, the canula was removed on the sixth day in 70 per cent. of 292 inferior tracheotomies, and in 45 per cent. of 133 superior operations. The first attempt at removing the canula was successful in 86 per cent. of the inferior operations, and in 70 per cent. of the superior. However, the report does not indicate whether the operations were tracheotomy superior or not. The after-results are, of course, not to be feared so much provided that the cricoid cartilage is not injured in tracheotomy superior, as is shown by the results of v. Bergmann and Krönlein. Tracheotomy inferior, on the other hand, as has been shown, is associated with greater danger of secondary hemorrhage and emphysema. The technical difficulties, therefore, will practically decide between the two operations. The author is of the opinion that, generally speaking, there are difficulties enough to be overcome in any case in which tracheotomy is to be performed without increasing these disadvantages voluntarily. Considerations of this sort may be of importance to a hospital surgeon operating frequently and with a large experience in tracheotomies, but for the general practitioner they are practically of no moment. For this reason the author considers that the operation of choice is superior tracheotomy when there is no thyroid to be dealt with, but prefers the inferior variety without question in children in whom examination of the thyroid gland, either before the skin-incision is made or afterward, shows that even when the gland is separated behind the fascia there will be little space. This objection is strengthened by the fact that an isthmus that has been separated with difficulty may lead to trouble in the after-treatment by pressing upward.

Laryngotomy.—Indications.—Only one of the two indications for opening the air-passages in general applies to laryngotomy, namely, for the purpose of obtaining access easily to the laryngeal cavity. It is for this reason a preliminary operation. It is only justifiable when laryngoscopic methods of operation do not promise success even in the hands of experienced specialists, or when an attempt at operating in this way has been shown impossible or inadequate. These indications have limited the use of laryngotomy, and during the last years the introduction of cocaine anæsthesia has still further limited the operation, because the difficulties of endolaryngeal work have been in this way still further diminished. These are, however, cases in which laryngotomy cannot be avoided. The affections that may lead to laryngotomy and the conditions have been considered in the preceding chapter. Recapitulated briefly they are, congenital diaphragms, laryngoceles, injury, foreign bodies, perichondritis, tuberculosis, lupus, scleroma, stenosis of the larynx, tumors of the larynx.

LONGITUDINAL SECTION.—1. *Total laryngotomy:* median incision, including thyroid cartilage, cricothyroid membrane, cricoid cartilage and sometimes the thyrohyoid membrane and the epiglottis.

PLATE IX.



Total Laryngotomy. (Zuckerkandl.)

2. *Thyrotomy:* division of the thyroid alone.

3. *Laryngotomy:* intercricothyroidea (after Vic d'Azyr); division of the cricothyroid membrane.

4. *Partial laryngotomy* (after Boyer): division of the cricothyroid membrane and cricoid cartilage.

5. *Laryngotracheotomy:* partial laryngotomy, with extension downward of the incision to one or more rings of the trachea.

TRANSVERSE DIVISION.—6. *Laryngotomy suprathyroidea.*

7. *Laryngotomy transverse* (after Gersuny): transverse division of the thyroid cartilage at the level of Morgagni's pouches.

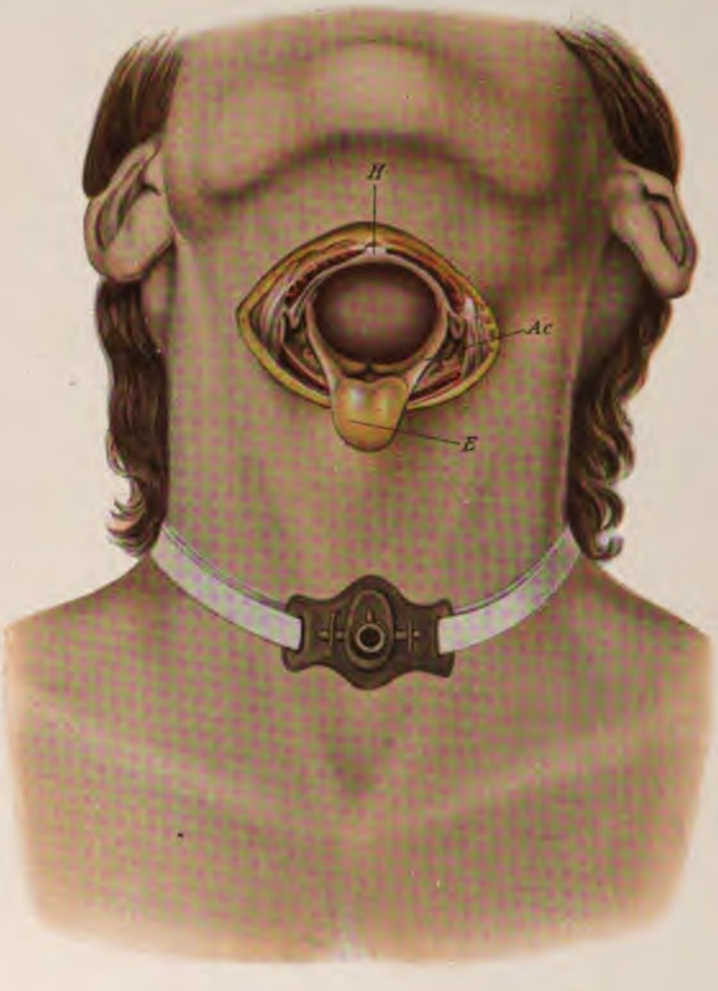
It is usual to include thyrotomy in the term total laryngotomy. This is, of course, not correct anatomically, but would seem to be justifiable on account of the practical importance and results of this procedure.

It is not necessary to consider further the value of the individual methods regarding the possibility of exposing the interior of the larynx and the special indications for their use, because sufficient attention has been given to this matter. The rules that should guide the surgeon in any operation can be found in what has been said about the choice of method for the excision of tumors of the larynx. Generally speaking, partial laryngotomy is to be preferred to complete division of the thyroid, provided the former is sufficient.

Laryngotomy suprathyroidea, which is performed chiefly by French surgeons, corresponds technically to pharyngotomy subhyoidea. It is characterized as a laryngotomy, because after division of the thyrohyoid membrane the laryngeal mucous membrane is divided laterally as close as possible to the thyroid and the epiglottis divided transversely at its base. Lejars prefers typical pharyngotomy, because of the after-effects produced by irregularities of healing in the region of the epiglottis. Gersuny recommends his method as a preliminary operation in all surgical operations in the region of the pharynx low down, the epiglottis, the upper and middle laryngeal space, the false cords, the vocal cords, and arytenoid cartilage. This operation has been performed by Billroth for lymphosarcoma of the right false cord, and by Gersuny for a cystic tumor the size of a dove's egg of the right pharyngo-epiglottidean fold. Recovery in both cases.

Technic.—This is much easier usually than tracheotomy, because it is as a rule not done as an emergency for the purpose of avoiding suffocation. Even the anatomical conditions make the operations considerably easier. The larynx is immediately beneath the surface, and access is not made difficult, as in the case of the trachea, by interposed vascular organs, aside from an unusually developed processus pyramidalis, which, however, cannot be considered as a severe obstacle. The cricothyroid artery alone comes into consideration as far as vessels are concerned, and is easily divided between ligatures. In exceptional cases a branch of the superior thyroid artery, and sometimes the hyoid branch of the lingual artery, have to be dealt with.

PLATE X.



Infrahyoid Pharyngotomy. (Zuckerkandl.)

H. Hyoid. *E.* Epiglottis. *Ac.* Arytenoepiglottidean folds.

It is only necessary to have observed but once the almost miraculous effect of painting the mucous membrane to become convinced of the value of this method and to make use thereof in future. It will, for the above reasons, be unnecessary to consider further the question of anæsthesia. When the psychical condition of the patient (nervousness, children, insane) makes a general anæsthetic necessary, as little as possible should be used. The larynx is exposed by a longitudinal incision in the median line in complete laryngotomy. This should begin at the lower margin of the hyoid bone and reach to the cricoid or a little lower; after dividing the skin and the fascia the sternal muscles are pulled to one side and the notch of the larynx exposed. The cricothyroid membrane and the cricoid are first divided. When dividing the thyroid cartilage especial care must be taken to have the incision exactly in the angle between the two vocal cords and avoid injuring either. This is best done by dividing from within outward. In the preliminary dissection from without inward, the knife may err to one side or the other because the thyroid cartilage is not infrequently asymmetrical. It is easiest to divide the cartilage with a powerful pair of scissors, which may be supplanted by Liston's forceps provided complete ossification has taken place. The halves of the thyroid are pulled apart carefully with sharp hooks. Fractures have repeatedly been reported because too much force was applied to calcified cartilage. The elasticity of the cartilage, which varies extremely in individual cases, accounts for the fact that the amount of separation obtained varies greatly. Castex separated the cartilage 15 mm. with simple thyrotomy post mortem; after continuing the incision through the thyrohyoid membrane this was increased to 30 mm. Krishaber, on the other hand, separated the edges only 4 mm. in a case of thyrotomy.

Transverse separation of the bands along the upper and lower margins of the thyroid (Hüter) aids in opening the larynx, but facilitates motion of the cartilages longitudinally, so that exact coaptation, so important for the phonetic result, is rendered more difficult. Besides this, section of the cricothyroid muscles endangers the function of the vocal apparatus, as emphasized by v. Bruns. In children it is oftentimes necessary to divide several tracheal rings after previously dividing the isthmus so as to obtain sufficient access to the thyroid cartilage.

Laryngotomy transversa, according to Gersuny, is done through the same skin-incision as recommended above for total division of the larynx. The soft parts are separated on either side by blunt dissection. The knife is placed transversely upon the angle of the thyroid cartilage 0.5 to 2 mm. above the middle point between the bottom of the notch and the lower margin of the thyroid. An incision is made on either side about 1 cm. long. When the thyroid cartilage is ossified, this may be done with a saw and the mucous membrane divided with a knife. Transverse division is completed on either side with a pair of scissors or bone-forceps, care being taken not to injure the mucous

[illegible]

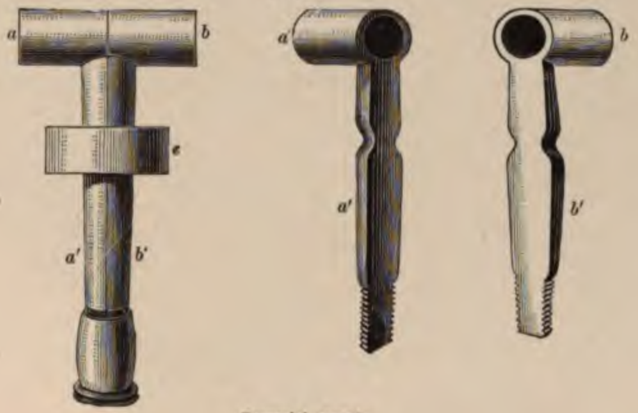
[illegible] Therefore, between [illegible] 15 per cent. in the [illegible]

Resection of the Larynx.—The indications for total and partial [illegible] for laryngectomy are limited. [illegible] number of operations for carcinoma, [illegible] lupus, syphilitic stenosis, [illegible] faulty diagnosis. [illegible] of the larynx and the [illegible] partial laryngectomy have [illegible]

Technic. The technical precautions that serve the purpose of diminishing the immediate danger of the operation are the same in partial laryngectomy as in laryngotomy. They have been applied by many authors in the same way to total excision of the larynx, which will be readily understood if one remembers that the dangers of both operations are practically identical, the only difference being the magnitude of the operation.

The skin incision is about as long as that for total laryngotomy. A transverse incision is usually made along the lower margin of the recommended by Richet, Baum, Dupuis, v. Langenbeck, Krönlein, Köhl, and others. Dupuis' canula (Fig. 89) and its modifications (T-canulas) have handles projecting at right angles, *a′*, *b′*. These project through the tracheal wound, and are held together by a rubber ring, *c*, and a screw on the end, so that the two short tubes go to make one continuous canula.

FIG. 89.



Dupuis' canula.

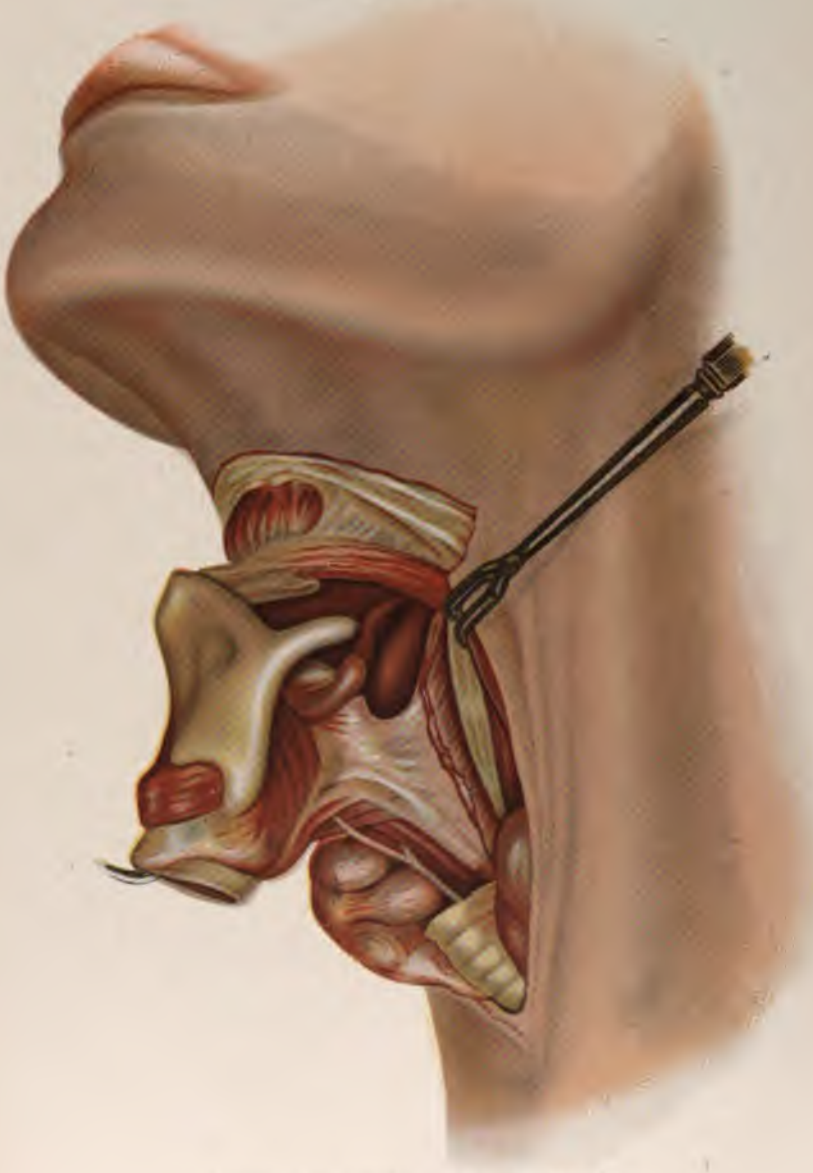
Of late years it has been customary, especially after excision of tumors, to rub the surface of the wound with iodoform and then sew up. (Kocher, Semon, de Santi.) The results have been good. A tampon soon loses its antiseptic action on account of absorption of secretions from the wound and of liquid foods, and may become loosened, so that a dependent corner may give rise to coughing.

The author would not hesitate in a given case, after extensive excision of the internal soft parts, to try primary Thiersch grafting of the cartilage, considering the experience in other mucous membrane canals. Gluck obtained a perfect result under conditions of this sort by turning in a pedunculated skin-flap. It has been sufficiently proved by the successful plastic operations of Navratil, Schimmelbusch, Lardy, and Gluck that the epidermis can perform the function of the epithelium of the air-tract.

The date on which the canula may be removed is independent of the laryngotomy itself. In individual cases (extraction of foreign bodies, excision of circumscribed benign tumors) it may be removed during the first few days, whereas in other cases (fractures, stenoses, extensive excision of tumors) it is not possible to restore natural respiration so early.

The influence of laryngotomy on the voice is considered to vary by different authors. Some laryngologists take altogether too pessimistic a view in this respect, whereas surgeons do not pay sufficient attention at times to the danger to the voice in thyrotomy. In all the cases in which incomplete excision or early recurrence of the

PLATE XI.



Laryngectomy. (Zuckerkandl.)

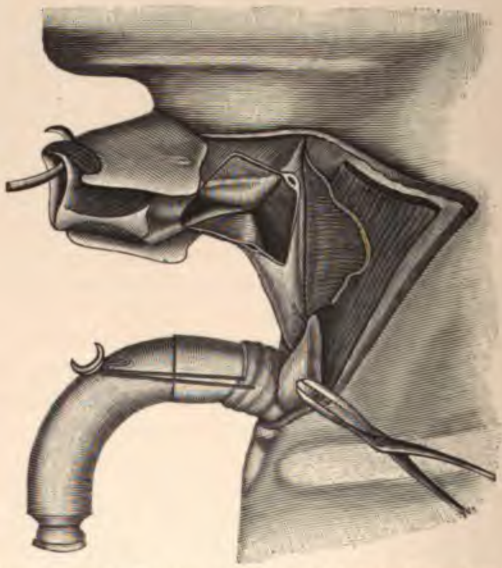
hyoid bone. Some surgeons recommend a second transverse incision at the lower end of the longitudinal wound (door-incision). This serves the purpose of getting sufficient room without being obliged to extend the longitudinal incision down to the tracheotomy-wound, which cannot be avoided in short, thick necks. After dividing the fascia, and if necessary the isthmus of the thyroid gland, the lateral surfaces of the larynx are exposed by separating the sternohyoid and sternothyroid and thyrohyoid muscles with a periosteal elevator. Sometimes it is necessary to use a knife with a blade held close to the cartilage and divide the insertion of the latter two muscles. Kocher recommends division of the sternohyoid and omohyoid and a portion of the thyrohyoid close to the hyoid bone. Beneath the sternothyroid will be found the lateral cornu of the thyroid gland, which must be separated with the fascia. The larynx is pulled to one side with a sharp retractor and twisted, while the inferior and middle constrictors of the pharynx are divided close to the cartilage, first on one side and then on the other (carotids !). While the larynx is being dissected out in this way the arteries are divided between ligatures. The following steps in the operation may be done almost without hemorrhage : the trachea is divided after having separated the same from the œsophagus by means of a director, and a loop is then passed around it. The larynx is pulled forward with a sharp retractor and separated from the pharyngeal wall from below upward. The excision is completed by dividing the thyrohyoid ligaments and the mucous membrane at the entrance, preserving the epiglottis and the aryteno-epiglottidean folds if possible. Fränkel lays particular stress upon preserving the entrance and the superior laryngeal nerves. Israel succeeded in saving the nerve after dissecting it out. The stump of the trachea is fastened to the lower corner of the wound with a few stitches, so as to prevent its retracting downward. If preliminary tracheotomy has been performed previously, the scar around the tracheotomy-wound will fix the trachea sufficiently.

Up to within the last few years the large wound cavity was left to heal by second intention, with frequent changing of the iodoform gauze packing. The free communication between the wound and the pharynx and the gaping tracheal lumen at the lowest point are dangers much graver than those of the operation itself. As already shown, the surgeon is now in a position to meet these objections. Even the most careful packing of the wound repeated several times daily does not prevent the entrance of saliva loaded with bacteria. This gauze is therefore no guarantee that the secretions of the wound will not undergo septic infection. The larger the wound, the more loose connective-tissue spaces will be opened, and the greater, of course, the danger of infection. The angle between the stump of the trachea and the surrounding connective tissue is especially prone to infection, according to Bardenheuer. Purulent cellulitis may develop in this region and descend, causing septic mediastinitis, or may extend to the sternoclavicular articulation, the periosteum of the sternum, or the upper rib.

Bronchopneumonia, which is the most common cause of death, plays a far more important part in the statistics of laryngectomy. This is explained easily by the aspiration of decomposing secretions of the wound, a disadvantage that cannot be prevented, as experience has shown, even by prolonged packing of the trachea. It is the object of the various modifications of the operative technic and of the after-treatment to guard against these disastrous after-effects which render the prognosis of excision of the larynx doubtful. The steps to be taken are self-evident. It is necessary to protect the trachea absolutely from the secretions of the wound and diminish suppuration and decomposition in the wound by shutting off the pharynx as completely as possible.

In 1888 Gluck and Zeller recommended prophylactic resection of the trachea on the strength of experiments on animals. The stump should be pulled out through a special transverse incision, or covered with tissue and attached all the way around to the skin by carefully placed stitches. This idea, which did not at first receive proper recognition, has since then been carried out on the human being by Gluck and by many other operators.

FIG. 90.



Excision of the larynx after Perier, with conical obturator canula in the trachea.

Perier has performed laryngectomy with separate suturing of the trachea since 1898. The points in which his operation differs from the technic described above will be briefly mentioned.

There is no preliminary tracheotomy. After having exposed the larynx in the manner already described, two strong sutures are passed around one or two rings of the trachea without including the mucous membrane if possible. The trachea is then divided transversely upon a director. The stump is immediately pulled out of the wound and a thick conical canula introduced until it completely occludes the lumen. The sutures are tied around a hood on its convexity and hold it in place. (Fig. 90.) After excision is completed, the trachea is sutured to the surrounding skin very completely and the longitudinal wound closed with deep sutures all the way up to the pharyngeal opening, which is made as small as possible. Perier recommends, when tracheotomy is unavoidable on account of marked dyspnœa, opening of the cricothyroid membrane so as to make use of this method if possible.

Garrè has recently operated successfully upon 2 cases in which tracheotomy was first performed and the stump of the trachea closed by dissecting out the upper ring and suturing the mobilized wall over the stump.

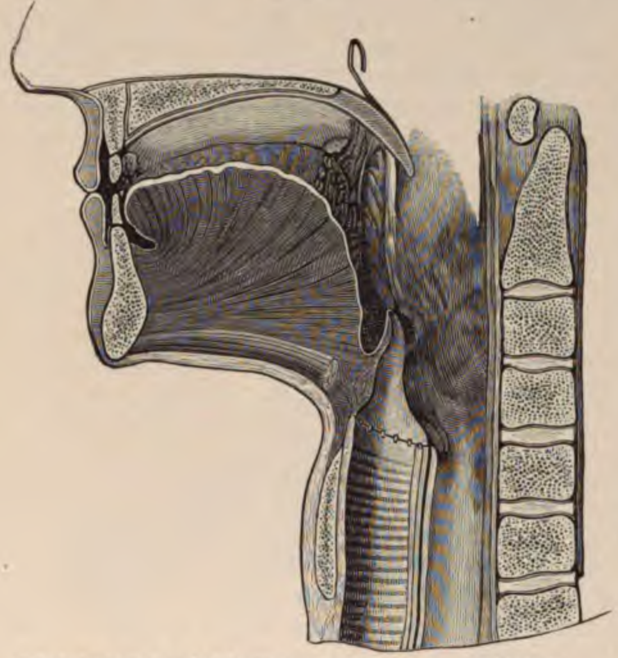
Bardenheuer was first to attempt to shut off completely the pharyngeal wound by preserving as much of the mucous membrane as possible from the epiglottis downward and then suturing these margins to the edges of the œsophageal mucous membrane. If needs be, the edges of the epiglottis were refreshened and the latter made use of to close the defect. As a rule the sutures did not hold, but a certain amount of protection was obtained during the early days at least. This method was further improved by Poppert (double row of sutures) and Rotter, who sewed the muscular structures over the united mucous membrane and obtained rapid recovery after almost complete closure of the skin-wound. Extension of a carcinoma beyond the limits of the larynx, necessitating removal of parts of the pharynx and œsophagus, increases the dangers of the operation. Closure of the pharynx has the advantage, besides that already mentioned, of allowing the patient to swallow in a normal manner soon after the operation. In a few cases it was not necessary to employ the stomach-tube. During the first few days after operation it is well to make use of rectal feeding exclusively.

The above method of procedure can, of course, be made use of only when total excision of the larynx is indicated from the first. When certainty on this point cannot be obtained by laryngoscopic examination, as is often the case, the operation should commence with a provisional laryngotomy. The conditions found will determine the further steps. If a decision is reached in favor of total excision, the author recommends that the trachea should be immediately divided transversely and that the larynx should be separated later.

Partial laryngectomy is so atypical an operation that it is not possible to give any general description, except in cases of unilateral excision, the technic of which is evident from what has been said regarding total excision. Kocher recommends, in case of circumscribed neoplasms, first to apply the cautery in the healthy surrounding tissue and then dissect out the growth. The author has already mentioned subperiosteal resection, as practised by Heine and P. v. Bruns in cases of stenoses. The measures for the purpose of protecting the wound and the lungs made use of in total excision of the larynx cannot be applied in partial laryngectomy (prophylactic resection and suturing of the trachea, closure of the pharynx). The surgeon must in these cases have recourse to the methods mentioned in connection with laryngotomy. The physiological function of the preserved portion of the larynx gives a relative amount of protection which increases, other things being equal, with the amount preserved. Sometimes when the entrance or even only half of the epiglottis is preserved swallowing may be normal from the first. Some surgeons prefer to leave a tampon-tube in place during the first days after operation. (Mikulicz.) This is later replaced by an ordinary tampon and changed frequently during the day (six times, Perier). Other authors (Semon, Kocher) close the wound by sutures without the use of tampons and try to prevent the entrance of secretions by a suitable position of the body. Semon places his patients horizontally on the operated side. Bardenheuer recommends that the head should be lowered by cutting off the mattress on which the patient lies at the level of the shoulders (total excisions, two). v. Bruns' statistics make it quite evident that all these accessory measures give comparatively little protection, and place in a doubtful light the assertion that excision of carcinoma by thyrotomy and partial resection is relatively devoid of danger compared with total laryngectomy. Considering the surprising mortality with conservative operations, any suggestions should be gladly received that give a chance of bettering the results. A method of this sort which seems worthy of imitation has been recently recommended by Gluck, and called laryngoplastic. This consists in making use of the external skin for the purpose of filling up the space where the larynx was, and thus closing the pharyngeal opening, thereby shutting off the pharynx from the air-passages. After the wound has healed the bridge of skin is perforated and the laryngeal opening closed by a secondary operation. Aspiration of secretions from the wound is avoided by Föderl in Gussenbauer's clinic in quite another way. This method is of use only after total excision or complete transverse section, and it seems to the author to be of sufficient importance to be briefly described. It is based upon the fact observed post mortem in animal experiments and on living man, that the trachea can be pulled up for a considerable distance. This mobility of the trachea is made use of by Föderl, who sews the stump of the trachea to the pharyngeal wound, thus avoiding a large granulating surface inside of the tube. The air-passage is completely shut off from the external wound.

Föderl, on the strength of post-mortem experiments, recommends that the epiglottis and the aryteno-epiglottidean folds be preserved if possible. After carefully arresting all bleeding the membranous portion of the trachea behind or a remnant of the cricoid cartilage is united to the beginning of the aryteno-epiglottidean folds. At the sides and in front through-and-through catgut stitches are placed and tied from behind forward. A few of the anterior sutures pass around the hyoid bone beneath the mucous membrane, and also through the base of the epiglottis and the first tracheal ring, for the purpose of preventing retraction. Besides this, the seat of suture is fastened to the surrounding soft parts by means of a few stitches. The muscles are united over this, and two small iodoform drains placed on either side after closing the wound elsewhere. It does not seem necessary to use an immobilizing bandage for the head, because the sutures seem to hold even when the head is considerably extended. (Fig. 91.)

FIG. 91.



Transverse suture of the trachea after laryngectomy. (Föderl.)

Other complications, aside from aspiration pneumonia and cellulitis of the neck, play an insignificant part in the statistics of laryngotomy. Sometimes the patients have been observed to collapse within forty-eight hours after operation, due to delirium cordis. Störk explains these fatal cases by assuming some injury to the depressor fibres which are supposed to take their course along the posterior wall of the larynx. His assistant, Alpiger, has demonstrated communication between the vagus and the sympathetic nerve in the region of the larynx by careful dissections. Physiological proof of these assertions is lacking. Grossmann claims that the danger is due to irritation of the superior laryngeal nerve. Perruchet comes to the same conclusion. Gluck considers cocaine an effective prophylactic against these reflex symptoms.

Secondary hemorrhage has been the cause of a few cases of death after excision of the larynx.

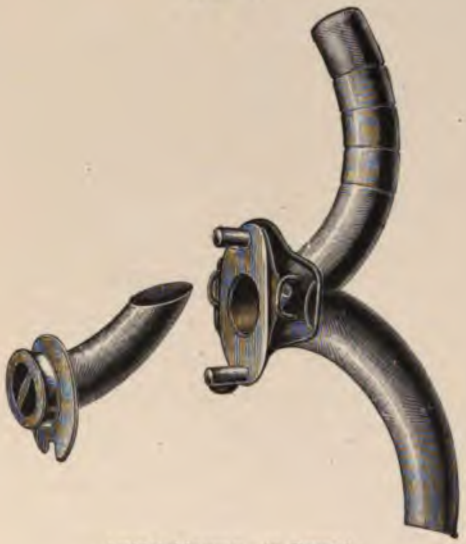
If it is possible to save a few patients from death or prolong their life for a few years by laryngectomy, this is sufficient success to overrule all objections made by those antagonistic to the operation. The question of functional result is subordinate.

In some cases after partial laryngectomy all the functions of the larynx may be almost completely restored (deglutition, breathing, phonation). It has already been explained what nature is capable of doing by forming cord-like scars on the operated side to aid in restoring the voice. Even after total excision the functional result has often exceeded all expectation. Most patients are able to swallow solid or semisolid fluid sooner or later without difficulty. Liquids may be swallowed by temporarily closing the pharyngeal fistula with a finger or a proper pad. In other cases, however, saliva and fluids run out over the skin of the neck and into the tracheal fistula to such an extent that the patient demands that the pharyngeal fistula be closed. After complete closure of the pharynx in one of the ways already described, the patient is able to swallow in a perfectly normal manner. Breathing through the mouth and nose after total excision stops without the aid of any special apparatus. It depends largely upon the nature of the margins of the fistula whether the tracheal tube has to be worn permanently. Provided they are firm and have no tendency to cicatricial contraction, or to sink in with respiration (this result is best obtained by accurate suture and primary union), then the canula may be discarded. A whispered voice remains even after the pharynx has been completely shut off from the air-passages, and as shown by experience may be developed by practice until it is quite sufficient for the demands of the patient. Hans Schmidt's case has become more or less celebrated, in which under conditions of this sort a loud although rough and monotonous voice was developed. One of Mikulicz's patients was even able to sing. Gottstein explains the development of a pseudo-voice by the formation of an air-chamber in the pharynx and œsophagus which is voluntarily inflated and emptied by the patient. The conditions in Föderl's case were especially favorable, because the entire expiratory air was available for production of voice. The margins of the tracheal entrance seemed to act as rudimentary vocal cords. The voice can be understood at a distance of thirty yards. He is able to partake of all sorts of food by holding his head somewhat flexed, although fluids go down the wrong way occasionally.

An artificial larynx has been the result of all the efforts to replace the lost voice. The first experiments for restoring the larynx were made by Czerny in connection with his first work on dogs after excision of the larynx. The first artificial larynx for human individuals is due to the efforts of Gussenbauer. Although the principle of the apparatus is simple, the technical difficulties are great. This fact is illustrated by the large number of modifications and changes which have been made by numerous authors in Gussenbauer's original instrument. (v. Bruns, Foulis, J. Wolff, Rotter, Narath, Gluck, Gottstein.) All of these instruments consist in the main of three parts:

a tracheal tube, a laryngeal tube, which fits into the former and points upward, and the phonation canula, which is introduced into the latter. This communicates with the tracheal tube by means of a large opening and can be closed anteriorly by a valve that is removable and allows free access to inspiratory air, but is closed by the expiratory current. The voice is contained in the interior. In v. Bruns' artificial larynx, depicted in Fig. 92, the metal vibrator, which gives a trumpet-like sound and annoys on account of its vibration during simple respiration, has been replaced by a rubber disk, which can be introduced by the patient himself through an eye. One of the chief objections to the artificial larynx is due to the entrance of mucus and saliva, which soil the vibrator and render it useless, and which may reach the trachea itself. The spring cover applied by Gussenbauer to the stiff laryngeal tube gives insufficient protection. Bruns advocated the use of a jointed canula instead of the stiff tube, which can adapt itself to the movements of the pharynx and is made longer than Gussenbauer's, so as to render it difficult for secretions to enter, and helps to prevent the margins of the wound closing down over the canula. J. Wolff has returned to the short stiff laryngeal tube, and closes the same by means of a fine sieve, which allows sufficient air to enter for the purpose of phonation, but prevents the entrance of secretions from the mouth. According to the literature, very good results have been obtained by the use of his instrument. Narath considers that the protection given by Wolff's sieve is insufficient. The method of closure which he uses is simple and has been very successful. He puts the reed in the tracheal tube and replaces the metal tube by a strong drainage-tube,

FIG. 92



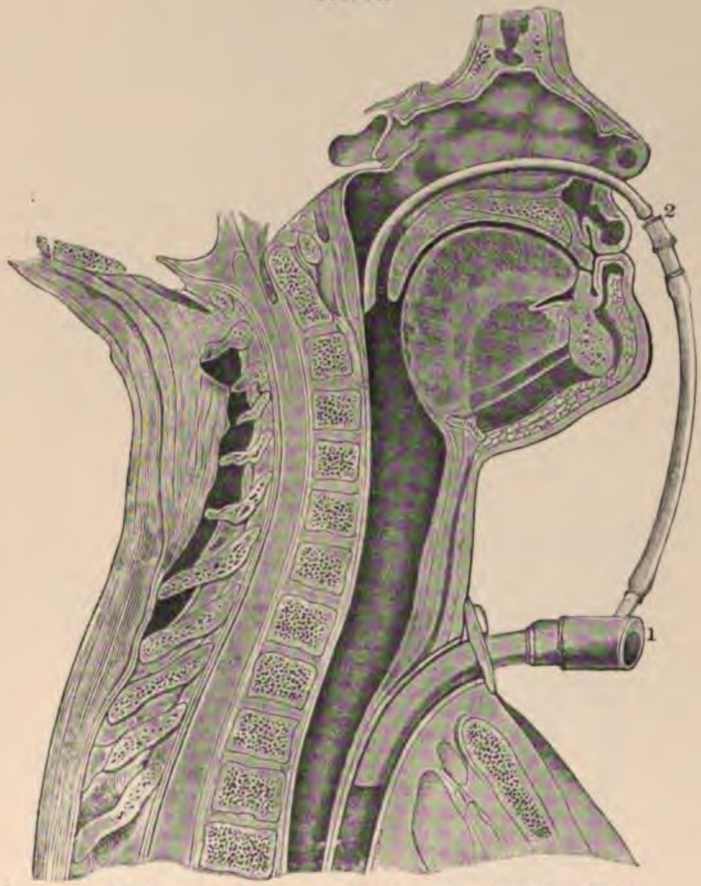
Artificial larynx. (v. Bruns.)

filling up the entire pharyngeal fistula and reaching far enough up so that in the act of swallowing the opening, which is directed backward toward the pharyngeal wall, and which is cut obliquely, is pressed against the pharynx. Bruns and Wolff prevent the entrance of food into an artificial larynx while eating by replacing an occluding obturator for the upper end of the canula. Other objections, the leaking of saliva around the pharyngeal canula and the escape of air around the tracheal tube, have been obviated by Gluck by the use of a soft-rubber pad filled with air or glycerin, which is pressed down against the fistula by the shield.

The newer methods of total excision, which place a more or less extensive bridge of skin between the tracheal opening and the pharyngeal fistula due to suturing the trachea in place and closing the wound above, do not allow the use of the older laryngeal models, because both arms are closely united in the lower angle of the wound. A modification of Wolff's larynx, by Rotter, which attempts to overcome these objections, does not seem to have been especially successful, whereas Narath has solved the problem in a very simple way by the use of the rubber pad above mentioned.

It is sufficiently evident, from what has been said, that the difficulties and disadvantages associated with an artificial larynx may be great. If to these are added the facts that some patients are much annoyed by the irritation which the pharyngeal tube exercises, and that some experience pain due to the pressure of the canula, and that prolonged talking with any of the instruments, owing to the associated difficulty in expiration, is exhausting and gives rise to a sense of oppression, and if it is further considered that many of the patients on account of their individuality and calling cannot give sufficient attention to the apparatus which even the most simple artificial larynx demands, provided it is to act perfectly, then it will be easily understood how it is that many patients soon discard the apparatus and satisfy themselves with a whispered voice. On the strength of experience of this sort, it is not astonishing that some surgeons (v. Bergmann, Mikulicz, and others) do not make use of an artificial larynx except when especially desired by a patient who is not satisfied with the whispered voice. Especially in cases in which primary union of the pharynx has been successful, it will be doubtful whether it pays to sacrifice the advantage of perfect swallowing and absolute protection of the air-passages from the entrance of secretions of the mouth, and make use of an instrument which the patient may discard after a few weeks. Gluck's phonetic nose apparatus enables the surgeon to decide this question in favor of preserving pharyngeal closure. This simple and ingenious apparatus consists of a metal cap provided with a valve which closes during expiration. This can be placed on the tracheal tube. At the upper end is a small tube to which a rubber tube may be attached, leading into the nose. The reed is placed in this, and consists of a small rubber band fastened over a metal ring. A cap is screwed over this which unites the apparatus with the tube supplying air. At the opposite end a second tube is attached, which is introduced into the nose until the posterior end is situated being the uvula. The air, which has been made to vibrate, is carried into the pharynx in this roundabout way through the nose. The instrument is readily adjusted and removed, and the vibrator is easily cleared and replaced.

FIG. 93.



Gluck's phonation apparatus in place: 1, cup with valve; 2, voice.

The advantages of this instrument are so evident that it is unnecessary to enumerate them. The author wishes to emphasize only that he has personally become convinced of the good phonetic effect that Gluck obtained in this way in a patient after total excision of the larynx and pharynx. This man was able to sing quite well. Gottstein introduces the voice-tube through the angle of the mouth, instead of through the nose.

Föderl's method of transverse suture renders the use of an artificial larynx impossible, of course, but at the same time unnecessary.

last decade concerning the physiology of the thyroid may be briefly presented as follows:

1. Total excision of the thyroid in mammalia is followed, especially in carnivora, by severe disturbances associated with convulsions (tetany), and usually results fatally. This is caused by absence of the organ, and not because of any injury—*e. g.*, nerves. (Schiff, Fuhr, Colzi, v. Wagner, Albertoni, Tizzoni, Horsley, Ughetti, Mattei, and the author's investigations.) The symptoms appear usually soon after excision. However, they may be slight or set in after some time. Exceptions to this rule are few if all sources of error be taken into consideration. Accurate observation shows that when excision is followed by no symptoms there are either remnants of the glands left, or accessory glandulæ parathyreoideæ glands which perform the duties of the excised portion. It is questionable whether it has ever been observed that after total excision of the gland in carnivora and in the absence of any accessory glands, the animals were free from tetany. At any rate, these cases are extremely rare.

In herbivora the acute symptoms are not so constant, which probably is in part due to the fact that these animals always have parathyroid glands remaining if especial care is not taken to remove them. In almost all cases, however, chronic disturbances arise (Gley), which are especially marked if the animals were operated on when quite young (Hofmeister, personal investigations). The thyroid gland is far more important in early life than later. When carnivora are put on an exclusive vegetable diet after total excision, they live for a greater length of time. (Breisacher.)

Although the results of total excision of the thyroid gland vary much in animals (carnivora, severe fatal tetany; herbivora, disturbances in growth and chronic cachexia), still the clinical picture in all varieties shows that acute tetany may frequently change to chronic cachexia.

v. Wagner's observations showed that in young cats typical cretinism developed after almost complete excision of the thyroid, which is further proof that both processes are identical. The subsequent symptoms are influenced by the age of the animal, food, and temperature.

2. A certain amount of the thyroid gland is necessary to preserve the organism from disturbances or errors in development. The size of this minimal amount of tissue varies greatly in man just as in animals, not only in the different families, but in the individuals of species. Sometimes small remnants will be sufficient, and in other cases a considerable residue will prove to be insufficient.

Certain external influences seem to play a certain part: gravidity (Halsted); age.

3. Sometimes the serious results of excision may be avoided by transplanting the gland to other positions in the body. (Schiff.) If its integrity is preserved in this position, then the physiological function will be maintained (personal observations).

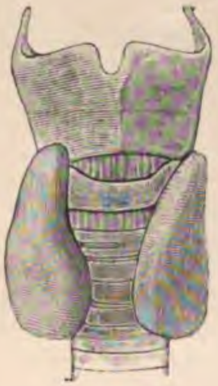
The lost function may be replaced in a less satisfactory way by con-

DISEASES AND INJURIES OF THE THYROID GLAND.

BY PROF. DR. FREIHERR V. EISELSBERG.

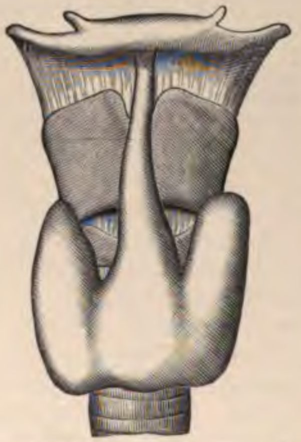
Anatomy.—The normal shape of the thyroid gland varies greatly. In about every third subject a middle lobe will be found, which is called the pyramidal lobe or middle cornu. This lobe is of especial interest on account of the difficulty it may cause to the surgeon when performing tracheotomy. In other cases the isthmus may reach down as far as the sixth tracheal ring; other abnormalities consist in the absence of the isthmus or the presence of only one lobe (Handfield Jones, Luschka), or three lobes with no communication (glandula thyroidea tripartita, Gruber). Two important abnormalities are dipicted in Figs. 94 and 95. (Marschall.)

FIG. 94.



Absence of isthmus. (Marschall.)

FIG. 95.



Isthmus with pyramidal process. (Marschall.)

Those cases are of surgical importance in which the thyroid is rotated so that its greatest diameter is in the horizontal plane, while the lateral lobes are situated between the trachea and the œsophagus, or almost touch behind the pharynx. In other cases the thyroid gland may be situated *in toto* low down (Kocher's thyroptosis). Absence of the thyroid in man is extremely rare. (Ribbert.)

Physiology.—The results of investigation carried on during the last decade concerning the physiology of the thyroid may be briefly presented as follows:

1. Total excision of the thyroid in mammalia is followed, especially in carnivora, by severe disturbances associated with convulsions (tetany), and usually results fatally. This is caused by absence of the organ, and not because of any injury—*e. g.*, nerves. (Schiff, Fuhr, Colzi, v. Wagner, Albertoni, Tizzoni, Horsley, Ughetti, Mattei, and the author's investigations.) The symptoms appear usually soon after excision. However, they may be slight or set in after some time. Exceptions to this rule are few if all sources of error be taken into consideration. Accurate observation shows that when excision is followed by no symptoms there are either remnants of the glands left, or accessory (glandula parathyreoïdea) glands which perform the duties of the excised portion. It is questionable whether it has ever been observed that after total excision of the gland in carnivora and in the absence of any accessory glands, the animals were free from tetany. At any rate, these cases are extremely rare.

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Although the results of total excision of the thyroid gland vary much in animals (carnivora, severe fatal tetany; herbivora, disturbances in growth and chronic cachexia), still the clinical picture in all varieties shows that acute tetany may frequently change to chronic cachexia.

v. Wagner's observations showed that in young cats typical cretinism developed after almost complete excision of the thyroid, which is further proof that both processes are identical. The subsequent symptoms are influenced by the age of the animal, food, and temperature.

2. A certain amount of the thyroid gland is necessary to preserve the organism from disastrous errors in development. The size of this minimal amount of tissue varies greatly in man just as in animals, not only in the different families, but in the individuals of species. Sometimes small remnants will be sufficient, and in other cases a considerable residue will prove to be insufficient.

Certain external influences seem to play a certain part: gravidity (Halsted); age.

3. Sometimes the serious results of excision may be avoided by transplanting the gland to other positions in the body. (Schiff.) If its integrity is preserved in this position, then the physiological function will be maintained (personal observation).

The lost function may be replaced in a less satisfactory way by continual injections of thyroid (Vassale) or by feeding thyroid gland (Lanz).

4. The results obtained by experimentation on animals correspond closely to the observations made on man. Human beings may develop acute symptoms or show chronic symptoms and present all the subsequent conditions observed in the various animals, as will be explained later. Similar conditions are observed in man when the gland is absent or diseased at birth, or when pathological processes develop during the later years of life. In man improvement takes place in all of these cases only when a portion of the gland becomes developed or when thyroid is administered subcutaneously or by mouth.

Pharmacological Peculiarities of the Thyroid Gland.—The action of thyroid has been tested in healthy animals and human beings. Tachycardia is a constant symptom. Symptoms of poisoning (dizziness, stenocardia, which may result fatally) are in all probability due to the use of spoiled thyroid or impure preparations. The gland, like other glands, decomposes much more rapidly than muscle-tissue. It is doubtful whether fresh thyroids give rise to any symptoms, according to the investigations of Lanz and Buschan. Becker reports that a child ate one hundred tablets of 5 grains each of thyroidin, without effect.

Thyroid seems to produce an increased elimination of nitrogen. (Schöndorff, Dennig.) Roos and Bürger found that the amount of phosphorous pentoxide eliminated in the stool was increased tenfold. An attempt has been made to prepare extracts that will be permanent, because fresh thyroid gland decomposes so easily, and when dried (Howitz) loses much of its efficiency. (White, Vermehren, Bourrough, and Wellcome.) These preparations are usually compressed tablets, one of which equals 0.3 gramme of fresh gland-substance. A number of investigators have attempted to isolate the active principle from the thyroid gland. After S. Fränkel believed that he had found in thyro-antitoxin the active principle, Bauhann succeeded in proving that pure iodine is constantly present in the thyroid gland and in greater quantities in regions where goitre is not prevalent. After the previous use of iodine the amount of this drug found in the thyroid gland was much increased. Baumann was able to prove that iodine in the thyroid gland is present as an organic combination (iodothyrin). It is put on the market mixed with a little milk-sugar, 15 grains of iodothyrin containing $\frac{1}{200}$ grain of iodine. This preparation is given in place of fresh thyroid gland-tissue in doses of 5 to 8 grains.

Iodothyrin has proved to be of value, not only in animal experiments, but also when given to human beings (goitre, myxœdema) (Baumann, Goldmann, Roos, Hofmeister, Hildebrand, C. A. Ewald, Notkin), although all authors have not observed positive results (Gottlieb). In all probability the thyroid gland contains more than one active substance, and iodothyrin is perhaps only the chief active principle. (Lanz, Reinbach.)

Other preparations made from the thyroid gland are thyraden (Kocher and Trachewski) and aiodin (Lanz).

[illegible] may be circumscribed or diffuse. A number of valuable monographs relative to the first microscopical appearance of goitre are [illegible], of which those of Virchow, Wölfler, and Hitzig may be mentioned.

With diffuse hyperplasia (true increase of gland-substance) there is seen histologically, besides follicles, tube-like or solid glandular formations analogous to the embryological processes of development. These formations are frequently spiral shaped or interwoven.

The first microscopical signs of struma nodosa consist in the presence of scattered ducts of this especially differentiated epithelium situated in secondary lobes or within the normal tissue, which tissue gradually infiltrates the entire normal structure in the form of small nodules. This view, held by Hitzig, is to be contrasted with that of Virchow, who considers that the beginning of circumscribed nodules of struma is an overgrowth of normal follicular epithelium. Wölfler seeks the cause in development from embryological nuclei. When the new growth of glandular substance is completely embryological in character, or when the follicles no longer develop typically, but appear as an overgrowth of cylindrical epithelium and glandular ducts lined with cylindrical epithelium, then adenomata are meant. Anatomically the term struma does not apply to these. Surgeons differentiate diffuse and partial increase of the thyroid gland caused by goitre. The first will now be considered, which may present itself as follicular, fibrous, or vascular.

Diffuse Hypertrophy.—Diffuse hypertrophy involves a uniform enlargement of the entire organ, which does not, however, alter the shape. Usually the contents of the follicles are increased (colloid variety) at the expense of the follicle itself. In other cases there is an increase in the number of follicles due to proliferation of epithelial foci. These new follicles may become hollow and then fill with colloid material, which may cause extensive increase in size (diffuse colloid struma). It is not uncommon to have increase in size of the thyroid gland due to diffuse new formation of ducts and follicles without increase in the amount of colloid material simultaneously—that is, a purely numerical hyperplasia (parenchymatous). Diffuse fibrous goitre, which is infrequent, is usually [illegible] with [illegible] in the size of the organ. Perhaps the [illegible] belong to this group, for they consist [illegible] interstitial tissue at the expense of the follicles [illegible]. Any increase in the size of the thyroid gland is associated [illegible] in the lumen of the vessels, [illegible]. Wölfler emphasizes th[illegible] supply histologically. A[illegible] which is probably d[illegible] new formation of vessels may [illegible]. One speaks of struma a[illegible] the arteries or v[illegible]

Partial Hypertrophy.—[illegible] processes that caused universal

CHAPTER VII.

DISEASES OF THE THYROID GLAND.

GOITRE.

Etiology.—Goitre occurs endemically, epidemically, and sporadically.

It is well known that goitre is more frequent in certain regions than in others, and never disappears from these regions, so that it is justifiable to speak of endemic goitre. It is further noted that in regions where goitre is endemic cretinism is especially frequent. The epidemic occurrence of goitre must be separated from this endemic variety. People who live apparently under similar conditions, such as soldiers and school-children (particularly those at boarding-schools), may develop at the same time a swelling of the thyroid gland which causes more or less disturbance. Finally, goitre occurs in individual scattered cases which are called sporadic.

Goitre is rarely congenital, usually acquired. Congenital goitre occurs where the disease is endemic. It is far more common in females than in males. Baillarger reported 4606 males with goitre and 8484 females. A similar relation has been observed by v. Schrötter, Laycock, Rutter, Wölfler, and others. When endemics are severe, this proportion is more or less evened up. (Baillarger.) The reasons for the predominance of goitre in women are as follows: 1, menses and pregnancy; 2, specific occupation; and, 3, the use of water chiefly as a beverage.

As far as the frequency is concerned, goitre is so common in regions where it is endemic that it should demand most careful attention. As regards the geographic distribution, reference may be made to Hirsch's geographic pathology and Lücke's monograph on diseases of the thyroid gland. The more the distribution of endemic goitre is studied, the greater the divergence of opinion, and surgeons are obliged to confess that the etiology of goitre is unknown. (Lücke.) A certain number of facts must be mentioned which appear to favor the development of goitre. Of these, hereditary predisposition and congestion of the head, especially of the neck, are to be enumerated.

As far as heredity is concerned, in some families goitre has been observed for generations, and in some regions where it is endemic is considered a desirable heirloom. Congestion is produced by mountain-climbing, especially while carrying weight on the head (Mahue), and then by singing and by using wind instruments.

A special variety of congestion is represented by physiological swelling of the thyroid gland during the menses and during pregnancy. Goitre is more common in girls than in boys, and at the age when the menses appear this relation becomes still more marked. Pregnancy probably influences the development of goitre, especially where the disease is endemic, or in regions where the disease is not prevalent, or in individuals who have had for some time a small nodule in the thyroid gland. Rapidly following pregnancies favor the development of goitre. The size of the thyroid gland is said to increase markedly at the time of delivery and immediately afterward, according to Freund and Hurten. This has given rise to the custom of midwives of tying a cloth around the neck while a woman is in labor. In acute infectious diseases rapid increase in the size of the thyroid has been observed. All of these factors above mentioned are predisposing causes only. It is well known that people who have had no goitre may develop this condition on moving into a region where the disease is endemic. This form of goitre may make its appearance within a short period. When goitre develops in several individuals who live under similar conditions, and have moved into a region where goitre is endemic, the status is spoken of as an epidemic. All epidemics have been observed where the patients lived under conditions of life practically alike, such as in barracks, prisons, and boarding-schools. An epidemic of the entire population in one vicinity has never been reported. Epidemics are usually observed in regions where goitre is endemic; rarely elsewhere. Hence it is reasonable to assume that certain specific influences operate in people who are predisposed (new arrivals not acclimated).

Goitre is observed most often endemic, as already mentioned. In certain regions the disease has been observed for centuries, and in these localities cretinism is always present. The number of endemic cases varies at different times.

The cause of goitre has been explained by local conditions of soil, of air, and of water. Insufficient oxygen in the air (Rozan) and excess of oxygen in the air (Lizzoli) have been mentioned in this respect. By examining the soil in regions where goitre is endemic certain definite data are believed to have been found. Bircher has made careful investigations, which were subsequently confirmed by Kocher and others. Bircher emphasized that goitre or its miasma is connected with maritime deposit of the palæozoic period, of the triassic period, and of the tertiary age.

In the Aargau community, Rupperschwiel, which derives its drinking-water from alluvium and meermolasse, endemic goitre and cretinism were always present to a marked degree. In 1885, 59 per cent. of the school-children were affected and 25 per cent. of the recruits suffered from goitre. During the summer of this year drinking-water was obtained from Auenstein, in the Jura, where goitre was not prevalent. In 1886 only 44 per cent. of the school-children were affected; in 1889, 25 per cent., and in 1895, 10 per cent. The fact that goitre did not disappear entirely is explained by Bircher, who observed that several inhabitants obtained their drinking-water from the brook, and not from the water reservoir. Only 17 cases of cretinism, varying from seventeen to twenty years of age, and no imbecile children, were present in 1895. So that, according to Bircher, the community could anticipate absolute disappearance of goitre in time. It will be difficult to produce more positive proof than this, that the cause of goitre is contained in water.

Twenty years ago Lücke expressed the opinion that in all probability some unknown goitre miasma was the cause, analogous to the cause of malaria. Bacteriological examination of the water has not been productive of positive information; still the author agrees with C. A. Ewald that goitre is produced by some specific organism which grows on certain nutritive media, and on entering the human body must find some special disposition of the affected individual before its pathological peculiarities can develop. This micro-organism seems to be connected in some way with certain telluric formations, and enters the human system with the water.

Inasmuch as the specific cause of goitre is unknown, it will be especially interesting to make note, not only of the factors which predispose to the development of goitre, but also of those which favor spontaneous disappearance of the condition. Just as the growth may appear suddenly or gradually (acute hyperæmia, hemorrhage, cysts, inflammation, malignant degeneration), so goitre may remain stationary for a certain length of time, or diminish in size or even disappear entirely.

During febrile diseases (pneumonia, typhoid) goitre may diminish in size (Lücke) just as malignant tumors, especially sarcoma, under similar conditions. Lücke states that in the cases in which goitre diminishes in size with marked emaciation, iodine has as a rule been used secretly in large quantities.

Pathological Anatomy.—The term goitre indicates enlargement of the thyroid gland, either symmetrical, involving the entire structure, or partial, as nodules and cysts. The term is applied especially to the endemic variety of enlargement. Sometimes an increase in size, due to acute inflammations or specific new growths (sarcoma, carcinoma) is called inflammatory or malignant struma, although this use of the term is not to be recommended. It is very difficult, as will be seen later, to separate simple hypertrophic increase and proliferation of glandular tissue from benign neoplasms (adenomata). Generally speaking, goitre is due to hypertrophy of the gland-tissue, sometimes consisting only in an increase of the follicular contents or in distention and proliferation of the vascular elements, and sometimes, which is uncommon, there is an increase of the connective tissue. Very frequently, however, there is an absolute increase of gland-tissue—*i. e.*, a new formation of gland which is very hard to differentiate from neoplastic increase. For the above reason, different authors have different conceptions of the conditions.

The increase in gland-substance and the increase in the contents of the follicles may be circumscribed or diffuse. A number of valuable monographs relative to the first microscopical appearance of goitre are available, of which those of Virchow, Wölfler, and Hitzig may be mentioned.

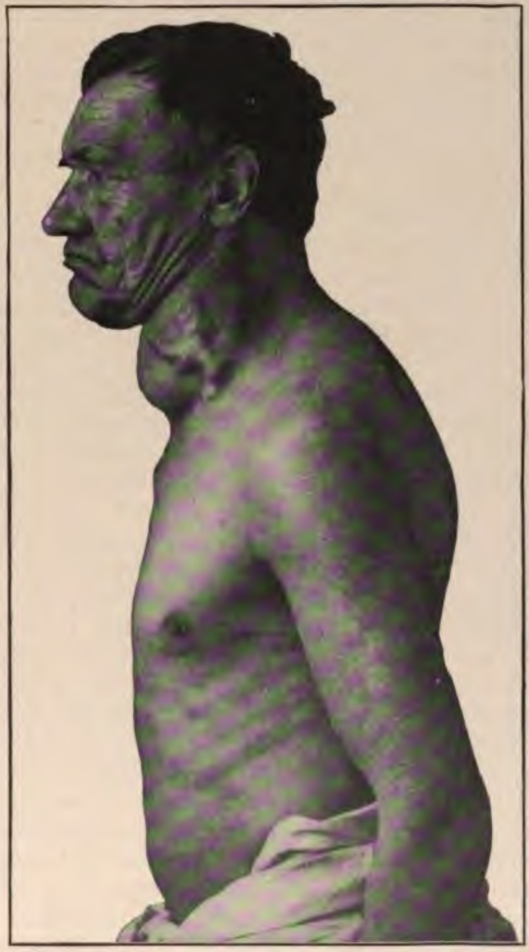
With diffuse hyperplasia (true increase of gland-substance) there is found histologically, besides follicles, tube-like or solid glandular formations analogous to the embryological processes of development. These structures are frequently spiral shaped or interwoven.

The first microscopical signs of struma nodosa consist in the presence of scattered ducts of this especially differentiated epithelium situated in secondary lobes or within the normal tissue, which tissue finally infiltrates the entire normal structure in the form of small nodules. This view, held by Hitzig, is to be contrasted with that of Virchow, who considers that the beginning of circumscribed nodules of struma is an overgrowth of normal follicular epithelium. Wölfler seeks the cause in development from embryological nuclei. When the new growth of glandular substance is completely embryological in character, or when the follicles no longer develop typically, but appear as an overgrowth of cylindrical epithelium and glandular ducts lined with cylindrical epithelium, then adenomata are meant. Anatomically the term struma does not apply to these. Surgeons differentiate diffuse and partial increase of the thyroid gland caused by goitre. The first will now be considered, which may present itself as follicular, fibrous, or vascular.

Diffuse Hypertrophy.—Diffuse hypertrophy involves a uniform enlargement of the entire organ, which does not, however, alter the shape. Usually the contents of the follicles are increased (colloid variety) at the expense of the follicle itself. In other cases there is an increase in the number of follicles due to proliferation of epithelial foci. These new follicles may become hollow and then fill with colloid material, which may cause extensive increase in size (diffuse colloid struma). It is not uncommon to have increase in size of the thyroid gland due to diffuse new formation of ducts and follicles without increase in the amount of colloid material simultaneously—that is, a purely numerical hyperplasia (parenchymatous). Diffuse fibrous goitre, which is infrequent, is usually associated with diminution in the size of the organ. Perhaps the changes observed in myxœdema belong to this group, for they consist in an overgrowth of the interstitial tissue at the expense of the follicular elements. Any increase in the size of the thyroid gland is associated with a corresponding increase in the lumen of the vessels, so that the term vascular goitre is very elastic. Wölfler emphasizes that this term is a clinical definition which does not apply histologically. Aside from temporary swelling of the thyroid gland, which is probably due to congestion, the distention and new formation of vessels may involve the arteries as well as the veins. One speaks of struma aneurismatica or varicosa according to involvement of the arteries or veins.

Partial Hypertrophy.—The same processes that caused universal increase in the size of the gland also give rise to circumscribed struma. It is uncommon to have accumulations of colloid material in one lobe give rise to circumscribed nodules, although this condition has been observed. Usually there is a circumscribed proliferation of gland-tissue (Hitzig), which is the reason why some authors consider any circumscribed development of gland-tissue to be a tumor, and these include adenomata. (Wölfler.) This author calls diffuse numerical hyperplasia "interacinous adenoma." It would seem far more appropriate, considering the present knowledge as to the function of the thyroid gland, to consider this increase of gland-substance proper, not a neoplasma in Cohnheim's sense, but a partial hypertrophy. Circum-

FIG. 96.



Parenchymatous struma.

scribed hyperplasia may develop in the interior of the gland or near the surface, and give rise to accessory glands that are only loosely connected with the main gland or absolutely separate. The latter condition means that the peduncle gradually atrophies and becomes obliterated. In both cases secondary changes may occur, especially, however, in the goitre colloid: hyaline and calcareous metamorphosis may take place, due especially to hemorrhages, the after-effects of such, or to necrosis and formation of cysts, all of which will be considered more in detail.

Cysts may develop in various ways. There are true and false cysts, according to their mode of origin: the former are secondary to distention and confluence of individual follicles, while the latter owe their origin to softening of the tissue following necrosis or hemorrhage. They may be single or multiple in diffusely enlarged thyroid glands, but are found especially in the so-called goitre nodules.

When of brief duration, the cyst-wall is delicate, while in other cases it may be thick, and in old cysts with one cavity it may be dense and fibrous. In the latter case calcareous deposit is frequently found, and occasionally true bone may develop as scales or lamellæ. In all cysts due to distention and confluence the inner wall was originally covered with follicular epithelium, which can be still observed in young cysts. In the older cysts it has undergone changes and is lost. Remnants of the partitions between the follicles may remain as prominent bands, which are to be distinctly separated from the papillary growths of cystadenoma, which is a distinct neoplastic process of proliferation.

As long as the lining wall retains its epithelial covering, secretion will continue and the contents of the cysts increase. It is not strange, considering the delicacy of the vessel-walls, that hemorrhages are not uncommon. The cyst contents, according to the origin of the cyst, are made up of colloid material or blood, or of mixtures combined with secondary derivatives (cholesterin). The original colloid material may become cloudy due to detritus (casts of epithelium), or be colored by blood. Cholesterin is frequently found. The consistence of colloid may vary, it being sometimes liquid, sometimes mucoid, sometimes tough and waxy. The chemical examination shows the presence of salts and products of extraction. When a cyst is due to hemorrhage, it soon undergoes change. The surrounding tissues are made use of to form a capsule and the contents become altered to a more or less chocolate-like mass, not infrequently mixed with colloid. Sometimes mummification may take place and salts of calcium be deposited, so that the contents resemble a mortar-like mass. These calcified masses and calcified nodules that become separated later are the so-called goitre stones.

The fibrous variety is a rare form of goitre, appearing in nodules usually secondarily, especially in an old goitre. It does not often occur as a diffuse change of one lobe. The most frequent cause of these circumscribed fibrohyaline nodules is the organization and fibroid change of old hemorrhages. The specific glandular elements diminish in proportion to the increase of connective tissue. There are very few vessels, so that calcification and necrosis are of frequent occurrence.

Hyaline change may develop in the interstitial substance of follicular colloid nodules, and is called by Wölfler "adenoma myxomatosum." Wölfler considers that this change is due to rupture of the follicles and entrance of the colloid material into the interstitial tissues. This variety should be included under circumscribed hypertrophy, whereas Wölfler's adenoma myxomatosum tubulare is a true new growth.

Although it has been mentioned, the author emphasizes once more that almost all of the above-described varieties and changes in goitre may be found in the same gland at the same time. Colloid cysts, blood-cysts, follicular, fibrous, and calcified nodules may be present together.

The adenomata occur as a nodular variety, which are distinguished only by the time and character of their development. These are benign circumscribed new growths, consisting of gland-tissue, which represent more or less closely the fœtal or infantile character of the thyroid. Sometimes they occur as glandular new growths that no longer correspond to the type of thyroid tissue. The fœtal adenomata described by Wölfler belong to this variety. They appear as one or more circumscribed nodules present since birth or since puberty, and which resemble partial follicular hypertrophy so closely that usually they cannot be distinguished from this condition. Histologically they consist of nodules of undeveloped thyroid tissue (accumulation of cells or ducts) with abundant supply of vessels, and should be considered a true new growth in Cohnheim's sense of the word. It is not probable that these adenomata are in any way connected with the epithelial bodies that resemble them so closely histologically. Epithelial bodies occupy a definite position, while the fœtal adenomata may develop anywhere in the thyroid gland.

The adenomata tubulare of Wölfler represent an embryological condition of the gland-tissue. Glandular new growths are found, which consist of ducts lined with long cylindrical epithelium and combined in rare cases with papillary tissue.

These papillary growths, already mentioned, and which occur at times in cysts, might be included among the new growths.

It should be mentioned that there are intermediate forms in which it is doubtful whether there is a hypertrophy, or more correctly a hyperplasia, or whether there is a new growth in Cohnheim's sense of the word. Goitre may therefore be subdivided in the following manner:

I. Diffuse varieties:

(*a*) Parenchymatous: 1. Adenomata—increase in the number of follicles. 2. Colloid—increase in the contents of follicles.

(*b*) Fibrous (rare) (myxœdema?).

(*c*) Vascular. In this variety there is an active growth of the vessel-wall with subsequent distention (aneurismal); in other cases a passive distention of the veins (varices).

II. Circumscribed varieties:

(*a*) Adenoglandular (local hypertrophy of the thyroid gland-tissue).

(*b*) Colloid with secondary changes: false and true cysts, calcification, ossification, fibrous and hyaline changes.

(*c*) Vascular.

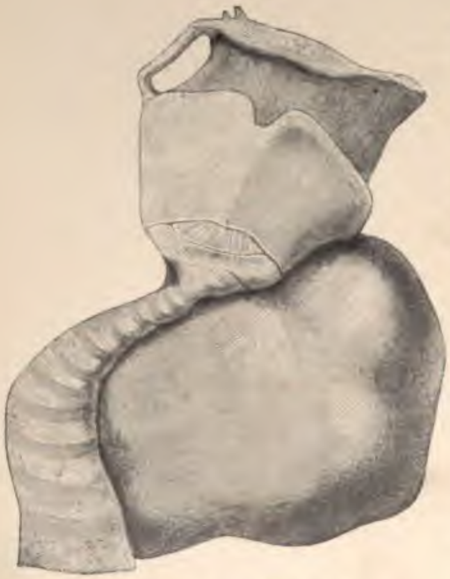
(*d*) Adenoma: 1. Fœtal adenoma of Wölfler. 2. Adenoma tubulare. 3. Cystadenoma papillare.

Fœtal adenomata represent the transition to malignant adenoma. Malignant adenoma can hardly be distinguished from some types of simple adenoma, should be called adenocarcinoma, and will be considered later.

Relation of Goitre to the Surrounding Tissues.—The study of goitre is of especial practical importance because it may give rise to a series of conditions that may endanger the life of the patient. These conditions may be subdivided into those that produce some functional change of the thyroid gland, those which are due to pressure upon the surrounding tissue, and those due to cosmetic deformity.

The first group of symptoms will be considered in connection with operative myxœdema. The disfigurement produced by goitre will not be considered more in detail. The symptoms of the second group are subdivided according to the organ whose function is interfered with by the goitre: (*a*) trachea, (*b*) œsophagus, (*c*) vessels, (*d*) nerves.

FIG. 97.

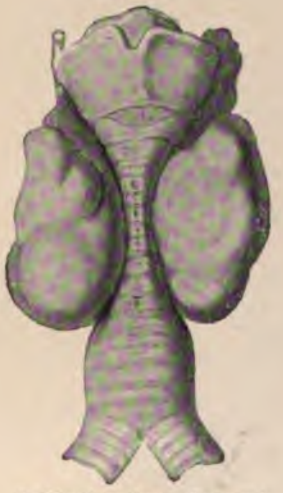


Displacement of the trachea. (Demme.)

(*a*) The symptom of goitre which is most apparent even to the laity is the obstruction to breathing produced by pressure upon the trachea. There are three varieties: displacement of the trachea or the larynx, diminution in the lumen of the trachea, and changes produced in the wall of the trachea.

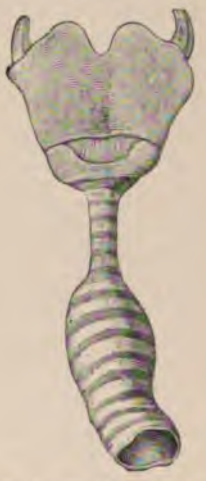
In severe cases all three conditions may be present at the same time. Simple displacement may be considerable without giving rise to especial discomfort. Bending of the respiratory tube is much more serious, because the lumen in this case is usually diminished. This compression may be unilateral, bilateral, or circular. The tube may be flattened anteroposteriorly or from the sides. Figs. 97–99 (from Demme) show these conditions. When pressed upon on both sides, a so-called scabbard trachea is found. When there are several nodules, there may be a corresponding number of twists; the most severe disturbance, of course, is produced by circular stricture. In cases of this sort the trachea is surrounded by the thyroid gland very much as the urethra by a hypertrophied prostate and the lumen of the tube is reniform in shape. Symptoms are most aggravated, generally speaking, when there are changes in the tracheal wall. Rose has paid especial attention to these changes. He explains the cases of sudden death as due to kinking of the soft trachea, the cartilage-rings of which have become degenerated. A fatal accident is also liable to occur because of the accompanying cardiac weakness. Numerous investigators have examined the trachea of these cases microscopically. Eppinger found the cartilage infiltrated with fat; Rotter observed softening only in the membrane between the cartilage; and E. Müller found nothing abnormal. At any rate, the pathological condition of the trachea does not appear to be uniform. (Kocher, Bruns.) Wölfler claims that the sudden increase of dyspnœa is due to rapid increase in the size of the goitre secondary to hemorrhage. Krönlein claims that this is due to pressure of the goitre upon the trachea, increased by the hypertrophied muscles of the neck. In malignant goitre it is not uncommon to have the tracheal wall infiltrated by the new growth. The larynx may be flattened by the mass of goitre. (Roux, Wölfler, Poncet.) The trachea below the seat of obstruction is distended as in any case of stenosis. This enlargement may reach as far down as the bronchi, and even involve these.

FIG. 98.



Scabbard trachea. (Demme.)

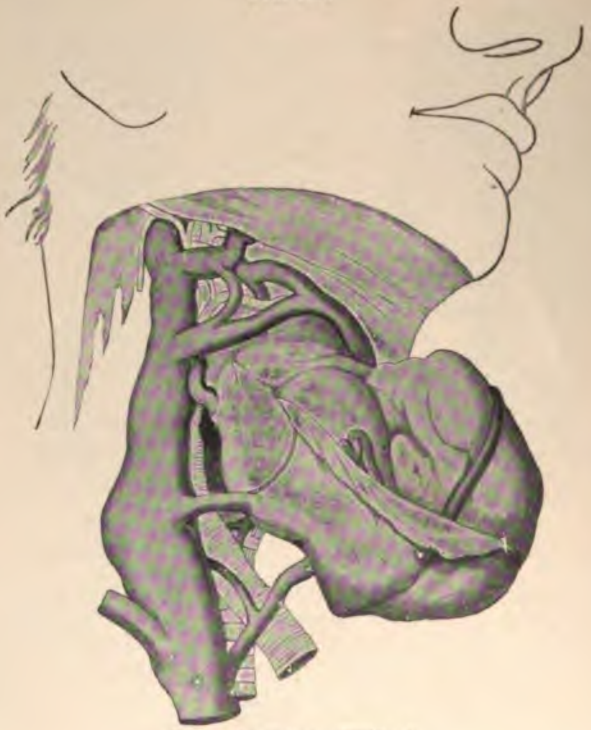
FIG. 99.



Circular constriction of the trachea. (Demme.)

(*b*) It is much more uncommon and not so dangerous to have goitre press upon the œsophagus. This pressure may have existed for some time without giving rise to disturbance, because the tube evades the pressure. The amount of constriction may be marked before the patient is aware of symptoms. Inflammation of the thyroid and malignant new growths are the chief sources of disturbance. Benign goitres that may give rise to difficulty in swallowing are classified as follows: circular; between the œsophagus and trachea (retrotracheal); retropharyngeal (Rühlmann's retrovisceral); and the deep-seated variety, especially when calcified, occupying the upper opening of the chest.

FIG. 100.



Veins of a goitre. (Wölfler.)

(*c*) The arteries are not infrequently displaced by goitre. The changes produced in the thyroidal arteries by goitre consist chiefly in distention and increase in the lumen, associated with an increase in the length of the vessel and thickening of its wall. The inferior thyroid artery has usually very delicate walls, which would lead one to suppose that the increase in size is due to passive dilatation. The veins of the neck are usually distended because there is a certain amount of obstruction to the flow of blood toward the heart. This dilatation may be associated with a thinning of the wall, which must be taken into consideration when operating. Fig. 100 shows how extensive dilatation of this sort may be.

(*d*) The relation of goitre to the nerves is of especial interest. Its position as regards the recurrent nerves is most important, although at times the superior laryngeal nerve and the trunk of the vagus itself may be involved. The sympathetic nerve is rarely influenced, and the hypoglossal nerve has to be considered in very few cases only.

According to Wölfler, the following effects of goitre upon the recurrent laryngeal nerve are observed : dislocation of the nerve (compression), adhesion to the capsule of the goitre, thickening of the nerve-trunk (compression), and atrophy of the nerve.

Symptoms.—The symptoms of goitre depend primarily upon the rate of development of the tumor. This applies especially to an increase in the gland produced by hemorrhage or inflammation.

The difficulties are by no means absolutely dependent upon the size of the goitre. A small retropharyngeal nodule may give rise to great annoyance, whereas a pendulous goitre so extensive that a patient is obliged to place it around the neck or on his back while at work, may not be associated with annoying symptoms. (Billroth.)

The first symptom noticed by the patient is usually an increase in the size of the neck (the shirt-collar too tight). The respiratory signs are most prominent. At first there is slight tracheal catarrh. Later, the patient complains that he "loses his breath" very quickly when running, or ascending stairs, or carrying weights, or bending over, etc., and that he suffers from palpitation of the heart. There is usually stridor, which may be heard at some distance. This consists of a long whistling sound during inspiration. It is worthy of mention that the subjective signs may be comparatively slight. The patient has gradually become accustomed to the diminution of the lumen of the trachea. He avoids excitement or rapid motion because he knows that it does not agree with him. Patients with loud whistling respiration, due to stenosis of the trachea produced by goitre, are sometimes able to perform their daily duties for years without being subject to severe attacks of suffocation. (Krönlein.) In such conditions any increase in size is associated with danger to life. A violent attack of coughing, a slight catarrh with tenacious secretion (Maas), or food going down the wrong way, may give rise to acute œdema of the mucous membrane and result fatally. Sometimes, however, breathing may become extremely difficult without any especial compression of the trachea on the part of the goitre. In these cases it is to be assumed that pressure upon the nerves is the cause of the symptom (paralysis of the laryngeal nerve). The abductors are usually paralyzed first, or both recurrents are affected at the same time. This acute attack of suffocation without diminution in the lumen of the trachea, steals upon the patient as a thief at night. (Krönlein.) The individual, who has slept comfortably, suddenly awakens with a sense of impending suffocation, rushes to a window, and gasps for air. If the attack passes off, dyspnœa may be so slight that no especial attention is given to the matter. The term strumatic asthma or

Kropftod has been applied to these conditions which sometimes occur when there is stenosis of the trachea, although this is not essential.

Retrosternal goitre and circular varieties give rise to severe symptoms quite early. Circular goitre is not infrequently congenital. Any increase in size of a retrosternal goitre gives rise to severe disturbances. This increase may be due to hemorrhage into the goitre, to inflammation, or to the development of a neoplasm. According to whether the portion of a substernal struma exerting the pressure is situated above or below the division of the trachea, the patient will find relief in bending the head forward or extending. Difficulty in swallowing is observed only in certain left-sided types, or with circular goitre, and especially in connection with retrovisceral nodules. The symptoms produced are as follows (Wölfler): pain on swallowing; arrest of solid food, sometimes even soft or masticated food, so that, as in typical stenosis of the œsophagus, only liquids can be taken; swallowing is impossible only in rare cases.

The amount of circulatory disturbance corresponds more or less to the difficulties in breathing, and may be produced in part by the latter. Slight irritation of the vagus or of the sympathetic may give rise to tachycardia. (Schiff, Moleschott, and v. Bezold.) Certain varieties of goitre associated with tachycardia are probably to be considered as masked morbus Basedowii, exophthalmos alone being absent. The obstruction to respiration gives rise to increased pressure within the veins, especially in the jugular vein. Following this there develop dilatation of the right auricle and secondary dilatation and hypertrophy of the right ventricle. (Rose, Wölfler.) The first circulatory sign, especially when the nodule has developed rapidly, consists in the appearance of cyanosis of the face (obstruction to the venous current and palpitation). Besides cyanosis, the skin may be noticeably pale. Cyanosis becomes more marked the greater the obstruction to the flow of venous blood produced either by direct pressure upon the innominate vein or upon the cardiac nerves themselves. This condition may be followed by œdema of the mouth (tongue), and in retroclavicular goitre the upper extremity may be involved. Palpitation, irregular pulse, and fainting spells may also be present. Wölfler and Gerson call attention to the fact that blood containing an increased amount of carbon dioxide first produces stimulation and then paralysis of the respiratory centre. (Landois, Hermann, Escher.) Finally, dilatation of the right ventricle develops, which may at any time cause cessation of the heart action.

In any individual case it will be difficult to determine whether the symptoms are due to disturbances of circulation or of respiration. In the majority of cases both systems are affected.

Displacement of the carotids outward and backward is typical. In these cases the pulse is felt most distinctly along the outer margin of the sternomastoid muscle. The artery is so superficial that it can be seen immediately beneath the skin. The length of the vessel is increased, and it may reach double the normal size. (Wölfler.) Only in exceptional cases is position of this artery, in relation to the goitre, found to differ. Wölfler mentions a case reported by Billroth in which the goitre rested against the outer side of the carotid. Poncet reports a similar case.

As regards disturbances affecting the nerves, those involving the recurrent nerves have been mentioned. This nerve may be irritated or paralyzed. Convulsive attacks of coughing and a hoarse voice indicate spasm. Spasm of the glottis (irritation) may result fatally. (Seitz.) Paresis or paralysis of the recurrent nerve is most interesting because it is most common. It may be demonstrated on laryngoscopic examination by sluggish motion of the affected vocal cord, or even immobility. The cord of the other side may cross the middle line to such an extent that the paralysis will be compensated, and no difficulty may be appreciated until a laryngoscopic examination shows the presence of paralysis. The voice will be somewhat indistinct and the patient will become fatigued easily when talking. Only when paralysis is complete will the cords occupy a middle position (cadaver position). The sequence of events regarding the position of the vocal cords is as follows: spasm, then contraction, and finally paralysis of the adductors. Paralysis of both recurrent nerves shows on laryngoscopic examination the conditions found post mortem. These patients are unable to produce any sound or cough. They do not suffer as long as they keep quiet. Severe dyspnœa is produced by paralysis of the crico-arytenoid posticus muscles. Expiration is undisturbed, but the patient aspirates the vocal cords on inspiration.

Krönlein has called attention to the fact that attacks of suffocation and the voice symptoms need not necessarily correspond, for cases occur in which there has never been an attack of suffocation, although there is distinct evidence of paralysis of the cords, and the reverse.

If paralysis of the recurrent nerves is divided into that produced by compression and that by atrophy of the nerves, it is evident that in the former case the function will be restored as soon as the obstruction is removed (excision of the goitre in about one-half of Wölfler's statistics). Paralysis of the recurrent nerves is a dangerous complication in any case. Bilateral paralysis may endanger life, especially with simple posticus paralysis.

Only in exceptional cases is the trunk of the vagus pressed upon by benign goitre. A certain amount of slowing of respiration has been observed in these cases. (Bruberger, Pinner.) According to Johnson, unilateral pressure upon the vagus may irritate the vagal centre and give rise to spasm or paralysis of the vocal cords due to reflex action.

Finally must be considered the influence exerted upon the sympathetic nerves by goitre. Symptoms of irritation and of paralysis must be considered separately. The symptoms of paralysis (a contracted pupil) are: paralysis of the dilator muscles of the pupil, narrowing of the palpebral slit, and at times congestion of the ears and hyperidrosis of the face. The symptoms of irritation consist in dilatation of the pupil, etc. The hypoglossal nerve is affected by goitre only in rare cases.

Abnormal Position of Goitre ; Accessory Goitre.—Before considering accessory goitre, it will be necessary to consider abnormal positions of goitre. The term "diver goitre" is applied to one that is very movable and is situated either below or above the sternal notch depending upon the motions of respiration. The term "floating goitre" has been applied by Wölfler to one that is freely movable along with the larynx. It may descend on inspiration so far as to become jammed into the opening of the chest, become swollen, and give rise to disturbances of breathing. This might be considered a diver goitre that had been caught and held in position. Kocher applies the term thyroptosis to a condition resembling enteroptosis, occurring in old people and in those with emphysema. In these cases the inferior cornu and almost the entire isthmus of the thyroid are situated within the chest. When a goitre is so situated that its greatest diameter is horizontal, the two upper cornua may almost touch behind and thus surround the trachea and œsophagus. This is called a "circular goitre." It is quite evident in these cases that difficulty in breathing and swallowing is common. When the upper cornua of a goitre that are directed backward develop upward and downward, the term "tubular goitre" is applied.

Fig. 101.

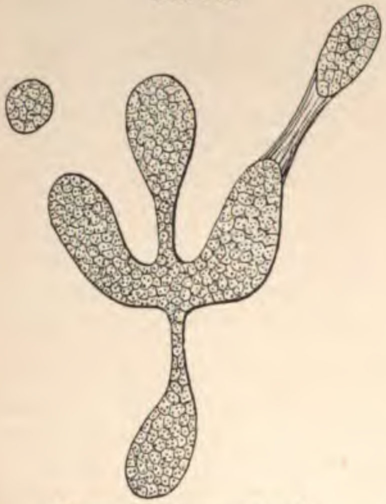
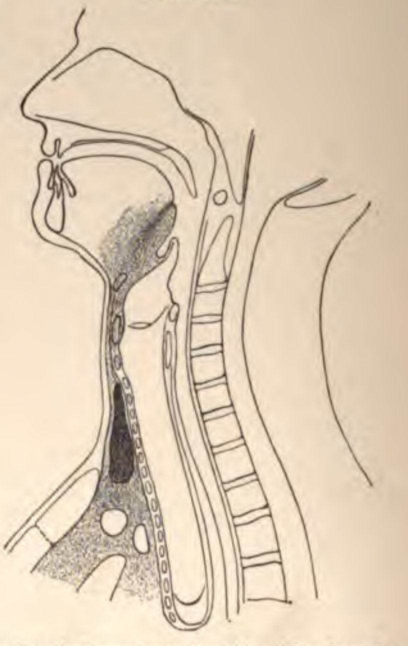


Diagram of accessory thyroids.

Fig. 102.



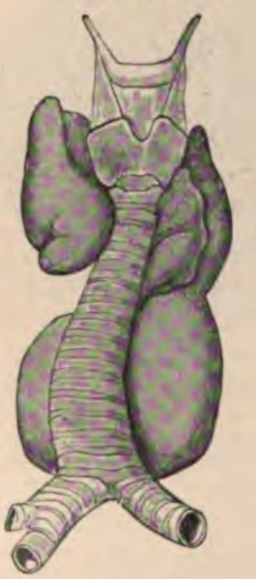
Region where accessory thyroids arising from the middle portion may be found. Gland, black.

Accessory goitres are divided into false and true, depending upon whether they are connected with the main gland or not. The true varieties are subdivided into connected and isolated. The former are bound to the main gland by bands of connective tissue, whereas the latter are free. Fig. 101 shows these conditions. These two types of accessory goitre must be sharply separated with reference to diagnosis, because the false variety may be recognized immediately as goitres, whereas the true is more difficult to recognize. It is best to consider both varieties together, because there exist intervening forms between the true and false. Wölfler divides accessory goitre according to their origin into such that have developed from the middle, and such that have arisen from the lateral portion of the thyroid. In Fig. 102 the region is shaded which may be occupied by an accessory thyroid developing from the median origin.

It is best to subdivide goitres anatomically, as done by Madelung, and distinguish inferior, posterior, superior, and anterior varieties.

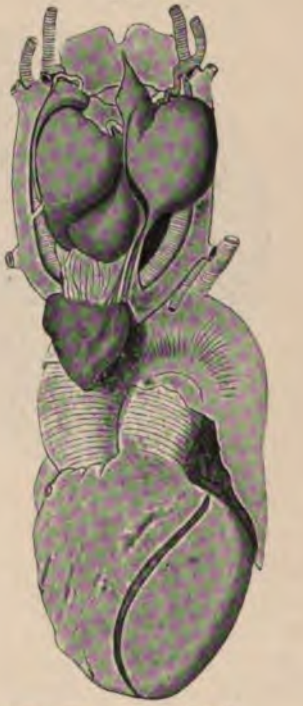
Inferior Accessory Thyroid Glands.—The substernal and endothoracic varieties develop from the median portion of the thyroid. The retroclavicular variety arise from the lateral portion. The most common variety is that which develops from the isthmus of the gland downward, corresponding to the pyramidal process, and produces a retrosternal goitre. This portion may be connected with the isthmus by a well-marked peduncle. A characteristic false accessory goitre is depicted in Fig. 103, taken from Krönlein's work. Wölfler and Wuhrmann have reported two other cases. Fig. 104 represents a typical accessory goitre (adjutolo). It is evident on examining this diagram that a total excision would have been productive of no severe symptoms.

FIG. 103.



False accessory goitre. (Krönlein.)

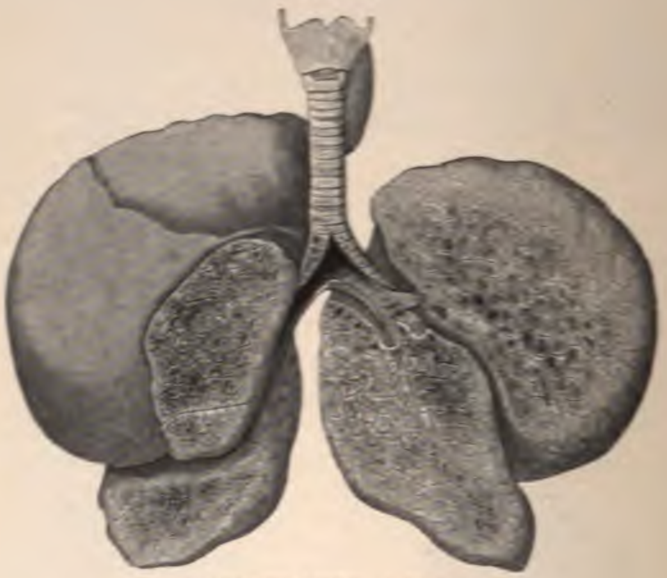
FIG. 104.



Accessory goitre (adjutolo).

Finally, there remains to be mentioned goitre situated within the thorax. This may vary in size. (H. Braun, Dietrich, Fig. 105.) A diagnosis is readily made when it is possible to trace the communication between the accessory goitre and the main gland. Wölfler and Wuhrmann, who have carefully studied intrathoracic goitres, call attention to the fact that a diagnosis may be made in some cases from the fact that the tumor rises on swallowing, whereas an accessory goitre is but slightly movable, and at times the corresponding half of the goitre above will be found absent. When no communication can be made out between the other half of the main gland, which may be normal, an absolute diagnosis can be made only by exposing the tumor itself (vascular capsule), or perhaps only by means of the microscope. Wagner reports 3 cases of true retrosternal accessory goitre with calcareous deposits.

FIG. 105.



Intrathoracic goitre. (Diettrich.)

Posterior Accessory Thyroid Glands.—These usually develop from the lateral portion of the thyroid. A retrovisceral goitre is one which has arisen from one of the lateral cornua and grown backward between the œsophagus and the vertebral column. About a dozen false goitres of this variety have been reported, and about half a dozen true goitres. The most important symptom is difficulty in swallowing. Sometimes it is possible to palpate the tumor in the pharynx. When the peduncle passing between the accessory goitre and the main mass can be felt, a diagnosis will be easy. The only treatment consists in excision. When the amount of thyroid gland-tissue has been much position, and shape of the tumor, as well as the condition of the overlying skin, should be observed. The carotid pulse may frequently be seen along the posterior margin of the sternomastoid. The surgeon should observe whether the tumor moves with the larynx on swallowing.

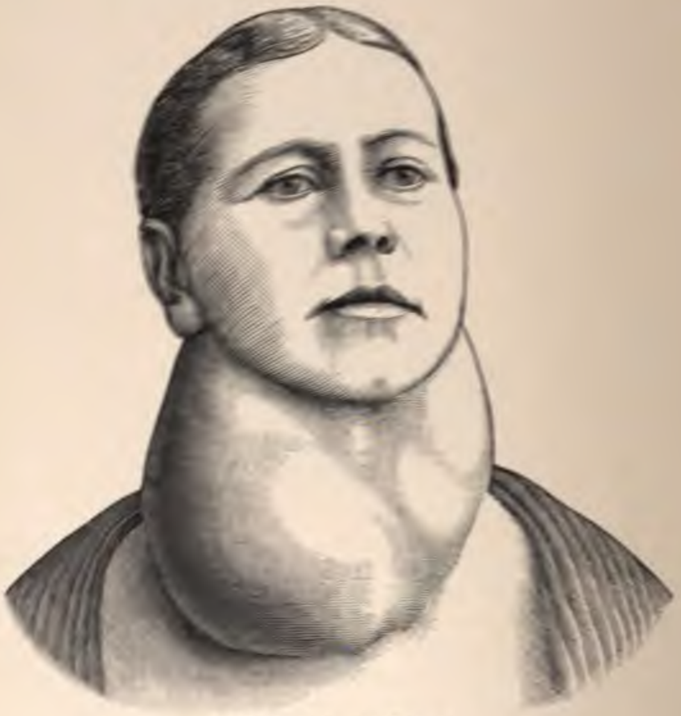
Palpation will give accurate information. The position of the thyroid notch and the carotid artery should be noted. When the mass is of considerable size, the artery will be displaced outward, and may frequently be felt beneath the skin along the posterior margin of the muscles. The chief object of palpation is to determine the consistence of the tumor, the nature of the overlying skin, and whether the mass is movable upon the underlying tissue. When a goitre has developed rapidly, it may not be movable (inflammation, malignant neoplasms). The consistence of the tumor should be carefully noted by means of both hands, and especial care taken to ascertain whether this varies in different parts of the tumor. Sometimes hard nodules and soft tissue or fluctuating spots are side by side. Nodules that are movable should be first immobilized before their consistence is examined. An assistant is necessary, especially when attempting to examine bimanually a retrosternal mass. The mobility of the tumor should be tested in relation to its underlying structures, and be moved upward, downward, forward, or backward. Very large goitres may be jammed in so tightly that there is little motion, if any, in any direction. Most of them, however, are more or less movable.

It has been mentioned that it is necessary to observe whether the tumor moves with swallowing. As a rule the patient is able to make but one or two vigorous swallows, one after the other, if he is requested to make them without water, because the liquid is liable to get into the larynx. On [illegible] connection between the thyroid gland and the [illegible] the thyroid and any tumor of the same [illegible] the act of swallowing. This is an [illegible] sign which is characteristic of the thyroid gland. [illegible] large goitres that infiltrate the neck [illegible]

[illegible] that move up on swallowing. [illegible] be sufficient simply to [illegible] whether there is vascular [illegible] may also be apprecia[illegible]

[illegible] is especially [illegible] the scabbard-shaped [illegible] After having [illegible] examination will [illegible] the vocal cords [illegible] the cadavers. The [illegible] as far as possi[illegible] from the sides [illegible] importance in bilateral present for a short time only. It has perhaps been noticed only since the last menstruation, or the individual has for the first time been in a vicinity where goitre is prevalent (summer goitre). This variety frequently disappears spontaneously. If this hyperæmia lasts for any length of time, it may give sufficient impetus to the development of follicular hypertrophy, which not infrequently involves the entire gland. (Fig. 106.) In this case it will be noted that the entire gland is enlarged, but harder and more dense than with simple hyperæmia, and that the mass can be more definitely outlined than in the hyperæmic variety. Both of these varieties are seen in youthful individuals as a rule. Sometimes the palpating finger will be able to detect a few well-defined round nodules in the interior of a gland, enlarged as a whole. These are of different consistence from their surroundings, and those situated near the surface may give rise to a slight nodular appearance. In other cases nodules of this sort are all that can be felt in a gland which is otherwise not enlarged. When these nodules develop at the time of puberty or during menstruation or pregnancy, they may be considered fœtal adenomata. This variety rarely becomes larger than a hen's egg, so that these nodules, which oftentimes cause no annoyance, not infrequently escape

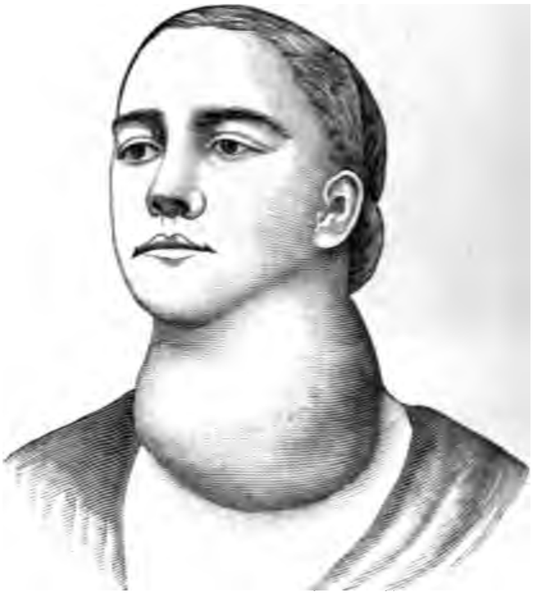
FIG. 107.



Colloid goitre. (v. Bruns.)

Fibrous goitre is characterized by numerous hard nodules occupying one lobe or the entire gland. These nodules rarely develop to any considerable size, but, taken together, they may form a large goitre. The individual nodes are freely movable, and those situated near the surface may be quite prominent and have peduncles. Sometimes nodules of this sort become true accessory goitres because of disappearance of the peduncle, which becomes stretched in the act of swallowing. It depends entirely upon the position of these pedunculated or isolated nodules whether they give rise to symptoms or not. When subcutaneous, they are objectionable only on account of their cosmetic effect; but when descending into the jugulum, they may give rise to difficulty. The firm consistence of the nodules is characteristic of fibrous goitre. These nodes may be so hard as to resemble bone, especially if there is calcareous deposit. They are observed as a rule in individuals past middle life. Mixed goitre occurs quite frequently, as already mentioned. Follicular hypertrophy may be present with fibrous changes, and several cysts may be found at the same time.

FIG. 109.



Cystic goitre. (Billroth.)

Cysts are the result partly of hemorrhages, partly of confluent colloid nodules, the contents of which gradually liquefy. The size of these cysts varies from that of a pea to that of a man's head. Fig. 109 illustrates a case of cystic goitre reported by Billroth, in Zurich, that was associated with parenchymatous struma. These cysts may become reduced, it may be advisable to transplant the goitre, as recommended by Wölfler.

Endolaryngeal, or Tracheal Accessory Goitres.—Thyroid tissue has been found in the interior of the trachea, usually where the trachea and larynx join. This is an uncommon occurrence, only 8 cases having been observed. (Ziemssen, v. Bruns, Paltauf, Baurowicz.) The base is usually broad and is covered with smooth mucous membrane. Formerly they were considered to be due to faulty embryological position, but Paltauf has proved that their position is due to embryological connection between the isthmus and the trachea, and that the thyroid tissue grows into the trachea at this place after birth.

Superior Accessory Thyroid Glands.—Those that are of interest all develop from the middle portion of the gland. The processus pyramidalis, reaching toward the hyoid bone, is a typical false accessory thyroid. If a series of rosary-like thyroid nodules are found in its place, these are considered to be true accessory glands. (Kadyi, Zuckerkandl, Streckeisen, Bochdalek.) There are sometimes found cysts situated upon the hyoid bone singly or in pairs, which are lined with ciliated epithelium or squamous epithelium (Häckel), which are correctly considered to be remnants of thyroid tissue by Wölfler. Thyroid of the tongue is of especial importance. (Hickmann, Parker, Wolff, Chamisso de Boncourt.) A tumor the size of a cherry up to that of a hen's egg, with broad base, and covered with normal mucous membrane, is found at the foramen cæcum or where the median portion of the thyroid commenced its journey downward. This tumor shows microscopically the structure of thyroid gland or of goitre. In 2 cases the thyroid gland itself was absent. After the operation symptoms developed, as would be expected in any case of total excision. (Seldowitsch.) There was a sense as if something had become enlarged in the neck. Snoring is always marked, and the patient cannot speak well. The hemorrhage is always a source of danger to the patient. The diagnosis is frequently difficult, and often it is not possible to differentiate from gumma or benign neoplasm. The history and the administration of thyroid tablets will at times enable a diagnosis. When there is a small peduncle, the tumor may be removed with the cautery, and when the base is broad excision, with preliminary tracheotomy if necessary, should be performed.

Anterior accessory thyroid glands are observed only exceptionally. Hofmeister has recently reported a case of this sort. There was a subcutaneous cyst beneath the skin of the chest about the size of a man's fist, which communicated with a cystic goitre by means of a hollow peduncle.

Diagnosis.—The diagnosis of goitre is usually possible from the physical examination without the aid of the history, and is difficult only in rare cases. Inspection, palpation, and laryngoscopic examination give the necessary data.

Inspection indicates the general condition of the patient. Cyanosis of the face, sympathetic ocular symptoms, dyspnœa, etc.; the size, position, and shape of the tumor, as well as the condition of the overlying skin, should be observed. The carotid pulse may frequently be seen along the posterior margin of the sternomastoid. The surgeon should observe whether the tumor moves with the larynx on swallowing.

Palpation will give accurate information. The position of the thyroid notch and the carotid artery should be noted. When the mass is of considerable size, the artery will be displaced outward, and may frequently be felt beneath the skin along the posterior margin of the muscles. The chief object of palpation is to determine the consistence of the tumor, the nature of the overlying skin, and whether the mass is movable upon the underlying tissue. When a goitre has developed rapidly, it may not be movable (inflammation, malignant neoplasms). The consistence of the tumor should be carefully noted by means of both hands, and especial care taken to ascertain whether this varies in different parts of the tumor. Sometimes hard nodules and soft tissue or fluctuating spots are side by side. Nodules that are movable should be first immobilized before their consistence is examined. An assistant is necessary, especially when attempting to examine bimanually a retrosternal mass. The mobility of the tumor should be tested in relation to its underlying structures, and for motion upward, downward, forward, or backward. Very large goitres may be jammed in so tightly that there is little motion, if any, in any direction. Most of them, however, are more or less movable.

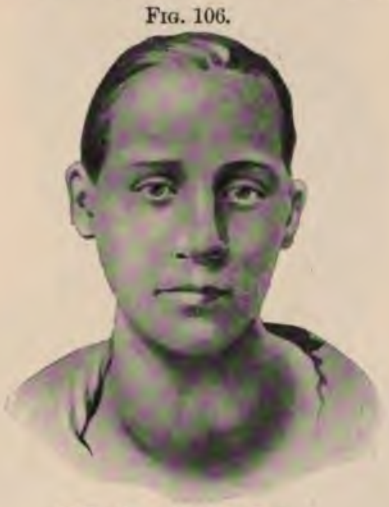
It has been mentioned that it is necessary to observe whether the tumor moves with swallowing. As a rule the patient is able to make but one or two complete swallows, one after the other, if he is requested to take a little water, because the liquid is liable to get into the larynx. Owing to the intimate connection between the thyroid gland and the upper rings of the trachea, the thyroid and any tumor of the same rises upon the larynx during the act of swallowing. This is an important diagnostic sign, which is characteristic of the thyroid gland. This sign is absent only in very large goitres that infiltrate the neck and feel brawny and board-like.

Baracz describes a case of tracheocele that rode up on swallowing. Considering the rarity of this disease, it will be sufficient simply to mention this occurrence. Auscultation shows whether there is vascular murmur in the tumor, and stenosis of the trachea may also be appreciated in this way.

Accurate examination of the larynx and trachea is especially important. The dislocation, and in some cases the scabbard-shaped trachea, may be appreciated on external examination. After having requested the patient to speak loudly a laryngoscopic examination will give accurate information regarding the condition of the vocal cords (mobility, adduction or abduction, or position of the cadaver). The surgeon should always endeavor to see into the trachea as far as possible, and note whether this is constricted anteroposteriorly from the sides or diagonally. This examination is of especial importance in bilateral goitre, because marked anterior bowing of the tracheal walls need not correspond to the size of the goitre. The base of the tongue should be examined, remembering that goitre at times develops here. When a patient complains of difficulty in swallowing, it may be necessary or advisable to pass a stomach-tube. Exploratory puncture will be necessary in exceptional cases only, and should not harm the patient. It is extremely important to clean thoroughly the skin and use a fine freshly sterilized needle.

Experimental administration of drugs for the purpose of making a diagnosis, such as the use of iodothyrin or tablets, will be necessary only in goitres at the base of the tongue where the diagnosis is very difficult, or with true accessory goitres or endolaryngeal tumors.

FIG. 106.

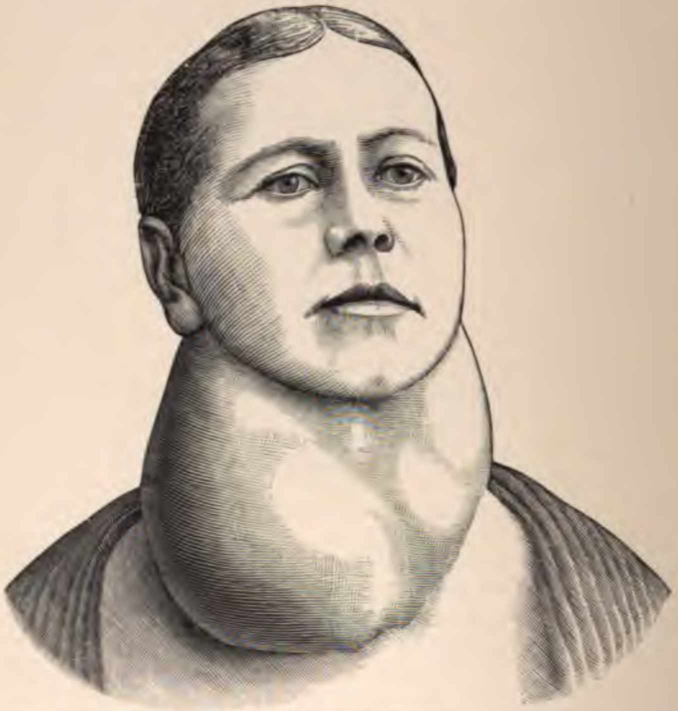


Follicular goitre. (v. Bruns.)

The history will supplement the examination. The statement of the patient whether the family presents any other evidence of thyroid enlargement, or whether he has been living in a region where goitre is common or absent, may be of value. If a goitre-like tumor should be found in a newly born infant, one must take into consideration the occurrence of teratoma of the neck. In women the statement whether the disease is worse during the menses or developed during pregnancy will be of importance. Information regarding the previous use of iodine should also be obtained if possible.

The surgeon should not be satisfied with the diagnosis of goitre alone, but should endeavor to discover which variety of goitre he has to deal with. Simple hyperæmia is characterized by a uniform swelling of the neck; the outlines of the sternomastoid, otherwise so distinct, become blurred without any definite outline of the thyroid being evident. The shape of the neck, as mentioned by Lücke and Billroth, may not necessarily be distorted. Palpation shows an enlarged gland of soft consistence, and the history gives evidence that the swelling has been present for a short time only. It has perhaps been noticed only since the last menstruation, or the individual has for the first time been in a vicinity where goitre is prevalent (summer goitre). This variety frequently disappears spontaneously. If this hyperæmia lasts for any length of time, it may give sufficient impetus to the development of follicular hypertrophy, which not infrequently involves the entire gland. (Fig. 106.) In this case it will be noted that the entire gland is enlarged, but harder and more dense than with simple hyperæmia, and that the mass can be more definitely outlined than in the hyperæmic variety. Both of these varieties are seen in youthful individuals as a rule. Sometimes the palpating finger will be able to detect a few well-defined round nodules in the interior of a gland, enlarged as a whole. These are of different consistence from their surroundings, and those situated near the surface may give rise to a slight nodular appearance. In other cases nodules of this sort are all that can be felt in a gland which is otherwise not enlarged. When these nodules develop at the time of puberty or during menstruation or pregnancy, they may be considered fœtal adenomata. This variety rarely becomes larger than a hen's egg, so that these nodules, which oftentimes cause no annoyance, not infrequently escape

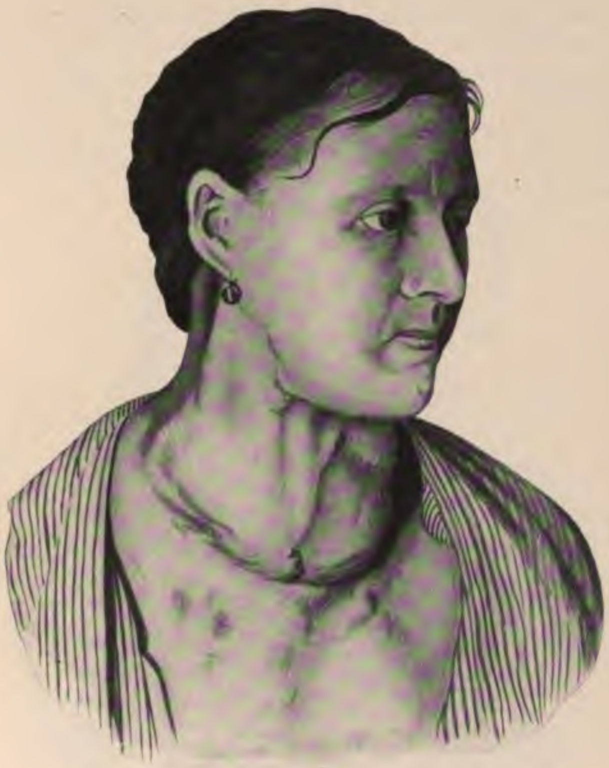
FIG. 107.



Colloid goitre. (v. Bruns.)

observation, provided treatment is not demanded for cosmetic reasons. When enlargement of the thyroid gland has persisted for some time and the individual lobe is the size of a man's fist or larger, so that the goitre resembles a horseshoe in shape (one lobe is usually more enlarged than the rest), one should always suspect colloid goitre. (Fig. 107.) The dough-like consistence of the mass will almost place the diagnosis beyond question. As a rule this variety occurs in individuals past middle life. Vascular murmurs or pulsation of the mass will establish the diagnosis of a vascular goitre. Transmitted pulsation in small individual nodules must be distinguished from the above variety, which usually affects the entire gland. The mass may be considerably diminished in size by steady pressure, and when this is removed, intermittent increase in volume will be observed. True aneurismal goitre is rare. In these cases one should be careful to note whether there is exophthalmos, tachycardia, or trembling (morbus Basedowii). Follicular goitre associated with marked distention of the veins must be distinguished from the above variety. (Fig. 108.)

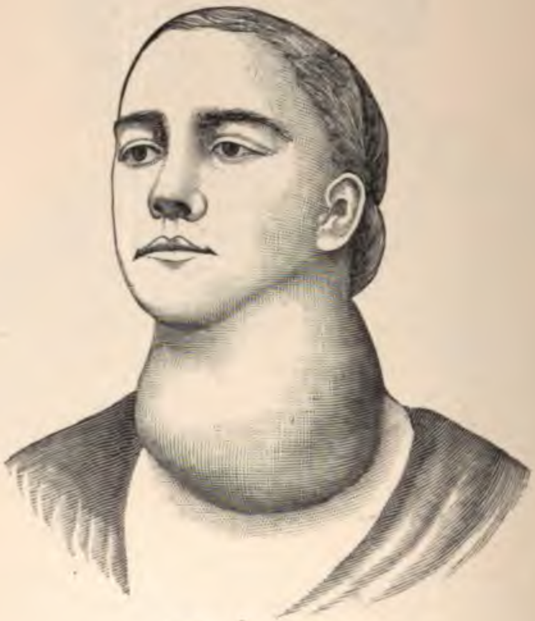
FIG. 108.



Follicular goitre with distention of superficial veins.

Fibrous goitre is characterized by numerous hard nodules occupying one lobe or the entire gland. These nodules rarely develop to any considerable size, but, taken together, they may form a large goitre. The individual nodes are freely movable, and those situated near the surface may be quite prominent and have peduncles. Sometimes nodules of this sort become true accessory goitres because of disappearance of the peduncle, which becomes stretched in the act of swallowing. It depends entirely upon the position of these pedunculated or isolated nodules whether they give rise to symptoms or not. When subcutaneous, they are objectionable only on account of their cosmetic effect; but when descending into the jugulum, they may give rise to difficulty. The firm consistence of the nodules is characteristic of fibrous goitre. These nodes may be so hard as to resemble bone, especially if there is calcareous deposit. They are observed as a rule in individuals past middle life. Mixed goitre occurs quite frequently, as already mentioned. Follicular hypertrophy may be present with fibrous changes, and several cysts may be found at the same time.

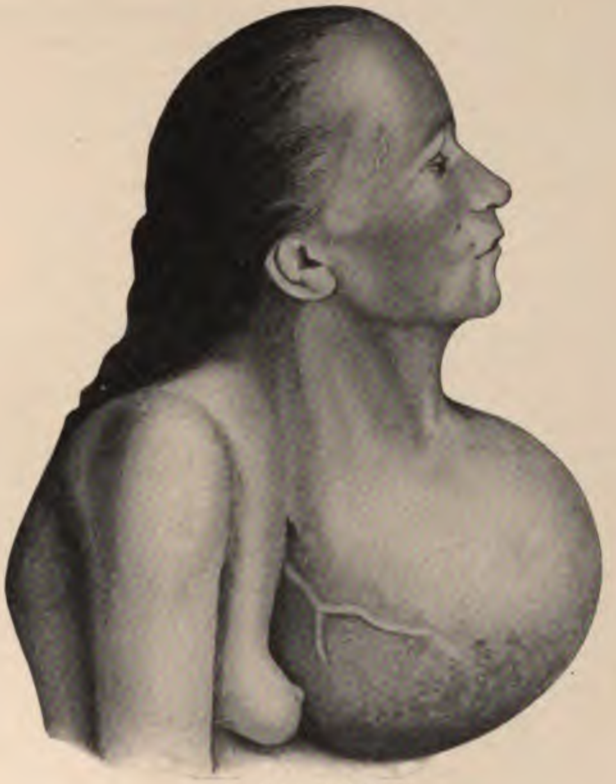
FIG. 109.



Cystic goitre. (Billroth.)

Cysts are the result partly of hemorrhages, partly of confluent colloid nodules, the contents of which gradually liquefy. The size of these cysts varies from that of a pea to that of a man's head. Fig. 109 illustrates a case of cystic goitre reported by Billroth, in Zurich, that was associated with parenchymatous struma. These cysts may become enormous, as shown in Fig. 110. Wiesmann reported a cystic goitre weighing nine pounds. The diagnosis in these cases is easy, provided the cyst is superficial and is large, and does not present calcification or other changes in its wall. The presence of fluctuation will decide the diagnosis. In the majority of cases the contents are cloudy. In exceptional cases one will be able to state from the wave on palpation whether the cyst is multilocular or not. Later it will be mentioned that it is possible only in exceptional cases to distinguish cysts and echinococcus of the thyroid.

FIG. 110.



Cystic goitre. (v. Bruns.)

In doubtful cases it is justifiable to make an exploratory puncture, although this will not always establish a definite diagnosis. Large hemispherical smooth prominences in a goitre, that fluctuate, always indicate goitre cysts.

It has been mentioned that goitres which are not connected with the thyroid gland at all, or only by a small peduncle, may give rise to difficulty in diagnosis. These cases represent the true and false accessory goitres already referred to. When there are isolated nodules [illegible] the [illegible] or [illegible] the [illegible] [illegible] of [illegible] [illegible] or of small [illegible] in the thyroid will [illegible] the diagnosis.

[illegible] of the [illegible] in the [illegible] of the [illegible] [illegible] tumors [illegible] the surgeon to consider [illegible]. The diagnosis will be doubtful in cases of [illegible] [illegible] [illegible] and [illegible], although the effect of iodine treatment will [illegible] a provisional opinion.

When the tumor is adherent to the skin and increases rapidly in size [illegible] [illegible] the possibility of [illegible] [illegible] must be considered. Like [illegible] in individuals of advanced years should lead the surgeon to consider the possibility of malignant tumors. The diagnosis of these conditions will be considered later.

Treatment.—Although surgical intervention is the only measure in the treatment of advanced disease of the thyroid accompanied with intense objective symptoms, in a certain number of cases in which the signs are slight, internal medication will be useful. First of all should be considered prophylactic measures and the avoidance of all influences that might possibly be concerned in the etiology.

Inasmuch as the water of certain districts seems to favor development of this condition, people who live in a district of this sort should always, more whenever they notice even a slight swelling of the thyroid gland, be careful to use boiled or filtered water and avoid the springs that are so dangerous. Those already affected who take up residence in a district of this sort are especially exposed. All causes of congestion of the neck should be avoided as far as practicable, especially the carrying of weights on the head, etc. The congestion secondary to the sexual phenomena in a woman's life, occurring in some at each menstrual period or with each pregnancy, should be met by the use of tight gauze bandages around the neck, an old popular measure which is not in the least irrational.

Medicinal Treatment.—Medicinal treatment consists at present exclusively in the use of iodine, as recommended by Coindet. The action of this drug is certain. According to Kocher, 90 per cent. of all goiters may be influenced by the use of iodine to such an extent that operation may be unnecessary. The advances of pharmacology are not directed to finding a substitute for iodine, but to the use of the best preparations. External applications consist of poultices made with a 10 to 20 per cent. solution of potassium iodide, or mineral waters containing iodine (Hall, St. Lorenzen, Darkau, Tölz), or salves containing a small amount of free iodine (potassium iodide ointment with slight quantities of iodine or 6 per cent. iodoform ointment). The benefit derived may be due entirely to the inhalation of free iodine. Internally iodine is administered as potassium or sodium iodide (3 to 45 grains daily). This medication is especially effective, but the symptoms described by Rilliet as iodine marasmus are most likely to appear with this form of treatment. Marked emaciation may follow excessive use of the drug. This marasmus does not seem to be due to the action of iodine itself, but depends probably upon too rapid diminution in the functionating volume of the gland. The effect of iodine is noticed very quickly, if at all, but in old fibrous or calcified goitres, or cystic goitre, it is useless to administer this drug.

ORGANOTHERAPY.—Treatment of goitre with thyroid substance, or preparations of this, must be considered a modification of the iodine treatment. Baumann's experiments have shown that iodine is contained in the active principle of the thyroid gland. Long after the favorable results of this form of treatment in myxœdema were known Emminghaus and Reinhold and v. Bruns demonstrated that administration internally of thyroid tissue was followed by favorable results in those suffering from goitre, especially from follicular hypertrophy. v. Bruns, who administered 5 to 15 grains of the gland daily in the form of tablets to 350 patients, reported 8 per cent. of complete cures, 36 per cent. of good effects, 30 per cent. of moderate success, and no success in the remaining cases. v. Bruns and v. Baumgarten studied the action of this form of treatment on dogs suffering from goitre. v. Baumgarten considers the change in the gland to be a symptom of trophoneurotic atrophy. The hypertrophy of the thyroid which develops to take the place of the portion which has become degenerated disappears after administration of gland-tissue. After Baumann isolated iodothyrin it was natural to substitute this active principle for the gland-substance; and Roos, a pupil of Baumann, observed favorable results after its use. The gland itself is best administered in the form of tablets, 1 or 2 a day; or as iodothyrin, 5 to 15 grains daily.

The results of this treatment of goitre have not escaped attack. A number of authors report cases in which this treatment was productive of no result whatever. Others, Kocher, for instance, came to the conclusion, after comparison with the old iodoform treatment, that there was no difference in the result of the two methods. The use of the gland or of iodine itself seems to be followed by favorable results only in cases of follicular hypertrophy. Disastrous effects are said to have occurred in individual cases. Symptoms of poisoning (frequent pulse, cyanosis, dyspnœa, tremor, and delirium) have been observed. They will be considered in detail later. The observations of v. Mikulicz and Reinbach are especially interesting. They obtained about equally good results after feeding with fresh thymus and after treating with thyroid substance. These authors gave their patients a considerable quantity of thymus (225 grains daily) without observing any effects which could be interpreted as due to intoxication.

INJECTIONTHERAPY.—This method was introduced by Luton and Lücke. These authors recommend the injection of a few drops of pure tincture of iodine. Recently injections of so-called iodoform oil ether mixtures (v. Mosetig, Garrè), which are less dangerous, have been preferred (iodoform, 1; ether, 7; oil, 7; keep in the dark). One to three injections a week are given for one to four weeks. An ordinary subcutaneous syringe is used.

Although this method is harmless and technically easy, still 16 cases of death are reported following injections, and Wölfler remarks quite correctly that in all probability the number is larger. The chief danger is from injecting into one of the larger bloodvessels, for death then occurs immediately. This error may easily be avoided by inserting the needle and removing the syringe to see whether blood flows from the needle, in which case it should be introduced at some other place. A second danger consists in injecting into the trachea or into the surrounding connective tissue, instead of into the goitre itself, giving rise to marked dyspnœa, which may even result in suffocation. This error is especially to be feared in substernal goitres. Care must be taken to fix the goitre so that it cannot slip, and one should always observe whether the syringe moves with swallowing, so as to be sure that the needle is in the goitre. The injection should be made slowly. If the point of the needle is in the lumen of the trachea, sufficient warning will be given after the injection of a few drops by an attack of coughing. Perfect asepsis should be observed, otherwise abscesses may develop secondary to the action of the injecting mass. The effect of this injection is to produce necrosis of the parenchyma of the gland and promote fibrinous exudation. The necrotic gland-tissue is replaced by connective tissue. Colloid is not influenced at first by the injection, but later becomes slowly absorbed. (Prins.) Even when injection has been performed with care, a reaction occurs at times, such as slight swelling or tenderness. One should always wait until these signs have disappeared before repeating the step. Sometimes several weeks will pass before any result can be observed. At first a gradually increasing firmness around the seat of injection will be noticed. According to Billroth, four or five injections are necessary to produce appreciable diminution in the size of the gland.

On account of its method of action injectiontherapy is indicated only in follicular goitre or beginning colloid struma. In these cases Garrè reports improvement in 90 per cent., consisting especially in a diminution of the symptoms due to stenosis. Generally speaking, injections have not been advocated of late. Recurrence is not uncommon, and if it becomes necessary subsequently to remove a goitre by operative interference, the firm adhesions secondary to the injections render this step difficult.

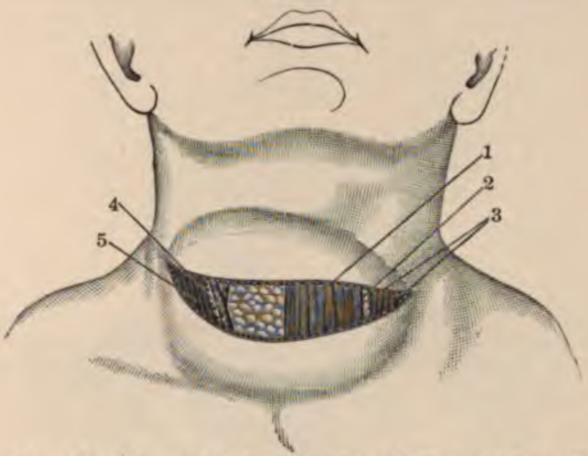
Injection of alcohol and other agents instead of iodine presents as many dangers, and the result is less reliable than after the injection of iodine (2 deaths have been reported following the injection of alcohol).

Surgical Treatment.—Operative interference should be considered in all cases of goitre with marked symptoms, in which the above-mentioned methods of treatment have been of no avail or cannot be used on account of the immediate danger. At present most of the dangers of operating have been obviated, owing to antisepsis and asepsis and the development of technic. The disastrous complication post-operative myxœdema has been avoided by allowing a certain portion of the gland to remain at the time of operation. Only that portion of a goitre which is diseased, or is giving rise to distressing symptoms, should be removed. A sufficient quantity of thyroid tissue should always be left to prevent the appearance of symptoms due to total absence.

The methods that have been tried and that are still made use of may be divided into two groups:

1. Partial excision of a certain portion (one-third or four-fifths) of the goitre. One-half of the gland, or the upper cornu, or where the gland is in relation with the recurrent nerve, is left behind.
2. Enucleation of individual nodules from the substance of the goitre, either by subcapsular shelling out or as typical enucleation *en masse*. The portion of gland-tissue around the nodule, which is little changed, is left.

FIG. 111.



Excision of a right-sided goitre by a transverse curved incision: 1, sternothyroid muscle; 2, anterior jugular vein; 3, sternohyoid muscle; 4, oblique communicating jugular vein; 5, sternomastoid muscle. (Kocher.)

Before considering the special technic of these methods, the technic in general must be considered. Whether to make use of a general anæsthetic or not in operations upon goitre is at present a much disputed question. Secondary disease of the lung (bronchitis, emphysema) and of the heart (dilatation of the right ventricle) so often present, and the danger of suffocation, especially in the early stages of anæsthesia, such as the period of excitement with stenosis of the trachea and paralysis of the larynx, have led many surgeons to desist from general anæsthetics as a matter of principle. Furthermore, if it be considered that the venous congestion produced even by slight straining on the part of patients under the influence of the anæsthetic, and by vomiting, etc., is directly dangerous to life, and that the operation in some of its stages is rendered much easier when the patient is conscious, then the objections raised by those that advocate local anæsthesia will seem more reasonable. Manipulation of a goitre in itself is not especially painful. Pain is caused at the moment the goitre is delivered through the wound. Kocher never uses a general

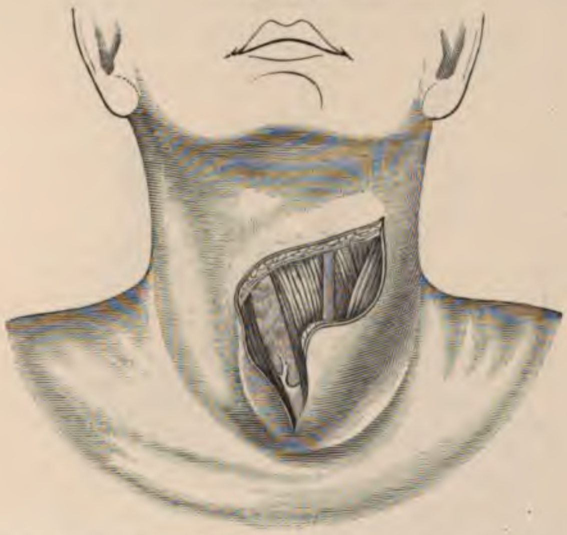
[illegible]

[illegible] communicating [illegible]

[illegible] the position of the head [illegible] with [illegible] the patient should be in a [illegible] position or almost [illegible] in the neck. Kocher's [illegible] the dangers of anæsthesia are not great [illegible] did not experience a single death in 5000 [illegible] chloroform was used, but lost only one patient [illegible] experience has been favorable with [illegible]

[illegible] recommended in operations upon [illegible] an incision is made over the [illegible] Kocher prefers a transverse incision because [illegible] When a tumor is of considerable size, or [illegible] expected that the operation will be difficult, as in retrosternal nodules, for instance, it is well to make a large skin-incision for the purpose of obtaining sufficient room. In these cases a T incision may be made use of. Billroth makes his incision along the free margin of the sternomastoid. A second incision may be made beginning at the lower end in the sternal notch and continued upward along the corresponding margin of the opposite sternomastoid. This incision gives sufficient room. Kocher recommends a broad transverse incision or a transverse curved incision with the convexity downward (collar-incision). After dividing the skin and fascia attention should be paid to the large veins overlying the goitre. They should always be divided between ligatures on account of the danger of death from air-embolism.

FIG. 113.



Angular incision, left-sided goitre, which reaches high up and low down; muscles exposed.

It does not seem advisable to leave artery clamps in the wound, not only because they have been observed to slip, but also because they delay healing. Whenever a goitre is very large, the overlying muscles (omohyoid, sternohyoid) should be divided. Their function is not interfered with because they are united afterward. After dividing the middle fascia, which often contains many vessels, the surface of the goitre—that is, the capsule—may be recognized by the network of fine veins. The subsequent steps will vary according to whether one intends to perform a partial excision or an enucleation.

PARTIAL EXCISION.—After exposing the capsule of the goitre an endeavor is made to free the upper and lower portions of the tumor with the finger or a blunt dissector and deliver the mass through the skin-wound. This part of the operation is probably the most dangerous, for if force is used the veins of the capsule or the large by tying a piece of rubber tubing (Bose) around the hilus of the gland, or having an assistant compress the vessels, have not always been successful in difficult cases. The bleeding is controlled very accurately, to be sure, by clamping the superior and inferior thyroid arteries, but Kocher and Wölfler consider that this method is of doubtful value on account of the danger of injuring the recurrent laryngeal nerves. It does not seem advisable to follow the suggestion made by Wolff to tie the chief artery and trust to packing during the operation, because the secondary hemorrhage may at times be considerable.

The old method of removing the contents of soft nodules after incising the capsule may be employed when enucleation is unsuccessful. Kocher has used this method when there has been stenosis of the trachea, so as to relieve breathing as quickly as possible. The bleeding in these cases may be terrific.

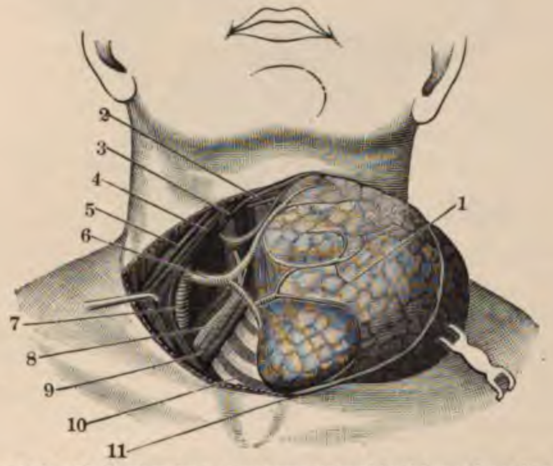
Poncet means by the term decortization removal of the greater part of the gland immediately beneath the capsule. Sufficient gland-tissue remains, hemorrhage ceases after tying the larger vessels, and a pucker suture, which takes in the greater portion of the cavity, is made use of. According to the statement of the originator of this method, it may be applied in parenchymatous or colloid goitres where Socin's intraglandular enucleation cannot be made use of. The bleeding is always profuse, as in any case of enucleation, the moment the knife enters the gland-tissue itself. Kocher justly condemns Poncet's method because of the bleeding, the necrosis of remaining bits of the capsule, and because of the disfiguring scar. With enucleation, injury to nerves and veins of the neck is less frequent than with excision. Statistics show that the danger of intraglandular enucleation is slight. In 1890 Wölfler was able to report 60 cases from Billroth's, Socin's, and his own clinic, with only 2 fatal ones. At present the results are still better.

Recurrence after Operations for Goitre.—A recurrence of the goitre may take place after both methods of operation. Isolated goitre nodules may develop in the remaining portion of the thyroid gland, or after excision of one half the remaining half of the isthmus may become hypertrophied. This hypertrophy, in accordance with experience gained by animal experiments, is considered a variety of compensatory hypertrophy. Clinically, recurrences after operations on goitre may be classified as those which do not annoy the patient and those which give rise to symptoms. The latter variety is uncommon. According to Bergeat, the second operation was necessary only 12 times in 600 cases. In most cases it will depend upon the nature of the remaining portion of the goitre and its situation whether the recurrence gives rise to symptoms or not. It is important that the hygienic disadvantages which are considered the cause of goitre in regions where the disease is endemic, should not be allowed to continue after the patient has been subjected to operation.

With the exception of cystic goitre (Wölfler) recurrence seems more frequent after enucleation than after partial excision. However, it has often easier to leave the adherent portion of the goitre behind, because the tube may be lacerated or secondary necrosis of cartilage take place. The secretion from the trachea entering the wound in these cases prevents primary healing. This is the reason why prophylactic tracheotomy is not performed even in a very large goitre. Tracheotomy is resorted to only in extreme cases when the trachea threatens to collapse after excision of masses that have pressed upon it laterally until it is the shape of a scabbard, and in cases of this sort one may be obliged to perform tracheotomy rapidly.

Kocher's experience seems to show that the anterior margin of the trachea usually remains firm and cartilaginous, and he makes use of this fact for placing sutures to hold the tube open. A strong piece of catgut is passed through each lateral wall and the ends tied in front over the firmer portion of the canal. Sometimes the tracheal wall is sewed to the sternomastoid muscles for the same purpose.

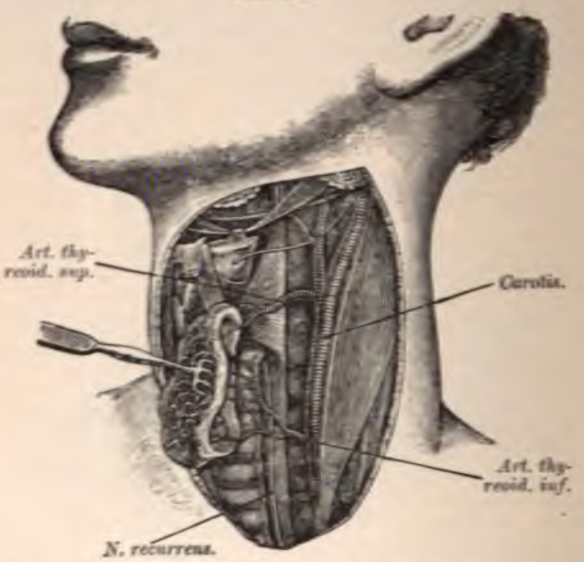
Fig. 115.



Excision of a right-sided goitre by a transverse curved incision; the goitre has been dislocated and rotated to the left: 1, right half of the goitre turned toward the left; 2, superior thyroid artery and vein; 3, posterior border of thyroid cartilage; 4, sternohyoid and thyroid muscles; 5, sternomastoid muscle; 6, inferior thyroid artery; 7, right common carotid; 8, recurrent laryngeal nerve; 9, œsophagus; 10, trachea; 11, inferior thyroid vein. (Kocher.)

After excision one should always determine whether there are remaining nodules. In unusual goitres situated between the trachea and œsophagus it may happen when this precaution is not taken that the portion of the tumor which gave rise to the symptoms remains behind and must subsequently be removed. One should always pack the cavity of the wound loosely and be sure that there is no bleeding. Any small bleeding point should be ligated. It is well to leave a soft-rubber tissue or glass drain in at the lowest portion of the wound for two or three days. This precaution is unnecessary in the majority of cases. When the wound is not drained and secondary hemorrhage takes place, or any other interference with the process of healing, it may be necessary to reopen the entire wound. In exceptional cases it may be feasible to leave strips of iodoform gauze in the wound with the drain, closing the rest of the wound entirely, and it is advisable to make use of the subcutaneous silver wire sutures, after Halsted's method, especially in transverse incision, for the purpose of obtaining an ideal cosmetic result. In these cases a moderate pressure-bandage is applied with plenty of gauze. In cases in which there is danger that the trachea may collapse after the operation it is advisable to use a somewhat firmer bandage with small pieces of splint wood, which act as a support to the trachea and limit the amount of motion in the cervical vertebræ. A bandage of this sort should be easily removable, because it may be necessary to interfere at any moment on account of secondary hemorrhage or dyspnœa. After two or three days, when the drains are to be removed, a lighter bandage may be applied.

FIG. 116.



The relation of the recurrent nerve to the artery. (Wölfler.)

This method above described, which has been developed by Billroth and Kocher, has been modified by some surgeons for the purpose of avoiding severe bleeding or injury to the recurrent nerve. v. Mikulicz leaves a small portion of the thyroid tissue behind at the entrance of the inferior thyroid artery after tying off this portion of the gland between small ligatures. A further modification recommended by this author consists in tying the superior thyroid artery and the superficial veins and making two vertical incisions along the posterior surface of the gland after separating the isthmus, leaving a wedge-shaped portion of the tumor behind, the edges of which are sewed together. Kocher combines resection with excision. He removes half of the goitre with the capsule and leaves a certain amount of tissue behind in the vicinity of the recurrent laryngeal nerve.

ENUCLEATION.—The danger of hemorrhage and injury to nerves and the endeavor to leave a sufficient quantity of thyroid gland behind, have developed the enucleation method. This presupposes that there are nodules of goitre that can easily be shelled out from thyroid tissue that is not altered. This method has been made use of by various operators (Porta, Billroth) in cysts of the thyroid, although it has not been used generally on account of the dreaded incision into the capsule. Socin has demonstrated that the danger of hemorrhage is not so great as was supposed, because the vessels of the capsule subdivide immediately in the upper layers of the parenchyma (v. Burckhardt). This method has been developed to a typical operation.

The technic is the same as that of excision up to the point of exposing the capsule. It is well to palpate the exposed gland when it is not possible to see the goitre nodules distinctly. An incision is made in the vicinity of a nodule where there appear to be fewest vessels, each individual vessel being carefully tied. The incision is carried down through the gland-tissue to the nodule until the latter can be shelled out with a finger or Kocher's blunt dissector. Should the nodule rupture, the cyst-wall is removed and the soft contents of nodules without capsules scooped out. Nodules in the vicinity should be sought for through the same incision. A piece of the gauze is packed into the cavity for a few moments. As soon as hemorrhage has ceased the incision in the capsule is closed. Should bleeding continue, the various points must be tied after packing. Sometimes it is possible to catch the inner wall of a cavity with a tenaculum and see the point from which bleeding comes. When considerable blood has been lost, it is not advisable to suture the incision in the capsule, but better to pack. The value of this method is influenced by the amount of hemorrhage, which at times may endanger life, although the gland-tissue itself is less destroyed. Whenever a branch of the inferior thyroid artery is torn, tamponing the wound will frequently not be sufficient, and an effort must be made to catch the bleeding point as soon as possible, or tie the vessel before its entrance into the goitre. Even parenchymatous hemorrhage may be so great that packing is not sufficient to arrest the bleeding, or the gauze may exert too much pressure upon the trachea. In cases of this sort immediate excision of one-half of the gland is the only way to save the patient's life.

Whenever there are numerous adenomatous nodules, it may be well to resect after they are removed, because all that is left is a ragged, sponge-like mass of tissue. Billroth and Kocher usually perform partial excision for the above reasons and enucleate only in cases of cystic goitre. In partial excision the danger of infecting the wound is distinctly less than with enucleation, because with the latter method large irregular cavities are always left.

Attempts to stop hemorrhage by a method similar to v. Esmarch's, by tying a piece of rubber tubing (Bose) around the hilus of the gland, or having an assistant compress the vessels, have not always been successful in difficult cases. The bleeding is controlled very accurately, to be sure, by clamping the superior and inferior thyroid arteries, but Kocher and Wölfler consider that this method is of doubtful value on account of the danger of injuring the recurrent laryngeal nerves. It does not seem advisable to follow the suggestion made by Wolff to tie the chief artery and trust to packing during the operation, because the secondary hemorrhage may at times be considerable.

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RECURRENCE AFTER OPERATIONS FOR GOITRE.—A recurrence of the goitre may take place after both methods of operation. Isolated goitre nodules may develop in the remaining portion of the thyroid gland, or after excision of one half the remaining half of the isthmus may become hypertrophied. This hypertrophy, in accordance with experience gained by animal experiments, is considered a variety of compensatory hypertrophy. Clinically, recurrences after operations on goitre may be classified as those which do not annoy the patient and those which give rise to symptoms. The latter variety is uncommon. According to Bergeat, the second operation was necessary only 12 times in 600 cases. In most cases it will depend upon the nature of the remaining portion of the goitre and its situation whether the recurrence gives rise to symptoms or not. It is important that the hygienic disadvantages which are considered the cause of goitre in regions where the disease is endemic, should not be allowed to continue after the patient has been subjected to operation.

With the exception of cystic goitre (Wölfler) recurrence seems more frequent after enucleation than after partial excision. However, it has not been decided how frequently recurrences give rise to symptoms after either of these methods. Sometimes the portion of the gland left diminishes in size after operation. According to Wolff, when one-half of the gland has been excised for hypertrophic goitre the remaining half always diminishes. He explains this on the assumption that the congestion of the remaining half of the gland also becomes less, following the removal of the stenosis of the trachea. Other authors have noted a similar diminution in the size of the remaining portion of the gland. (Reverdin, Kocher, Poncet, Wölfler, Löwenstein, Köhler.) It has not been determined to what extent climatic influences are responsible for the differences of observation in different localities. In spite of recurrences and atrophy observed at times a complete recovery usually follows most methods of operating. The stenosis of the trachea disappears, the shape of the trachea becomes normal, the difficulty in breathing diminishes immediately after the operation. Paresis of the recurrent laryngeal nerve almost always disappears after operation. Dyspnœa becomes less, even when the nerve remains paralyzed, which proves that it is not of laryngeal but of tracheal origin. The cyanosis secondary to pressure upon the veins of the neck disappears immediately. Operations upon goitre are among the most satisfactory surgical procedures on account of the immediate disappearance of most of the annoying symptoms.

DANGERS OF GOITRE OPERATIONS.—The danger of this operation has diminished progressively in 6103 cases. Reverdin gives the mortality as 2.88 per cent. Kocher's results are brilliant, his mortality being 0.2 per cent.; v. Mikulicz, 2.6 per cent.; v. Bruns, 2 per cent.; Roux, 1.27 per cent. Reverdin has compared the mortality of the individual methods of operation. Statistics show that the death-rate with intraglandular enucleation is 0.78 per cent.; combined enucleation and resection, 2.92 per cent.; partial excision, 3.46 per cent.; the old method of resection, after v. Mikulicz, 6.66 per cent. The latter figures are probably explained by the fact that this method has been supplanted, even by the author himself, by modern modifications. At the present time disastrous cases occur which are dependent upon the specific method of operating. The accidents may happen during the operation or immediately afterward, and be independent of the dangers associated with any operation (anæsthesia, infections). Reverdin's statistics show that of 93 cases of death after operations for goitre, 42 were due to respiratory difficulty (suffocation, pneumonia), 19 to hemorrhage, 13 to infection, 9 to nervous conditions (shock, injury to the recurrent nerves), 6 to cardiac failure, and 4 to tetany and myxœdema. The severest complication on the part of the vascular system consists in hemorrhage, which can only be avoided by tying the vessels or arresting the bleeding at every step in the operation. Especial attention must be paid to ligation of the friable arteries. The author prefers to tie instead of leaving artery-clamps in position, on account of the interference with healing of the wound produced by the foreign body. He leaves the clamps in the wound only when ligatures are insufficient (friability of the vessels and deep position). One cannot warn too strongly against trusting to temporary cessation of hemorrhage produced by compression. As soon as the pressure in the vessels, which is diminished during the operation, increases, a fatal secondary hemorrhage may follow. Bleeding must be checked at any price. With retrosternal goitres a patient may bleed to death into the mediastinum without a drop of blood appearing externally. (Poncet.) In pre-antiseptic times secondary hemorrhages were frequent, but are now rather infrequent. They are usually due to insufficient checking of hemorrhage at the time of operation, but at times they occur when a drain or a strip of iodoform gauze is removed that had been in place for a considerable time. Nurses should be instructed to watch for the first symptoms of secondary hemorrhage.

Injury to the veins during operation often leads to air-embolus, because the vessels in the vicinity of the goitre have no valves and are much distended. This is the complication which always endangers life, although in individual cases no symptoms whatever have followed. Whenever the characteristic whistling noise is heard, the wound should be packed temporarily as rapidly as possible. The seat of injury is sought for by removing the gauze carefully and clamping the opening. Artificial respiration favors further entrance of air, and is to be avoided, as a rule. König's cardiac massage has given excellent result. An attempt was made by Wölfler to remove the air by aspiration. The entire wound may be flooded with salt solution and this allowed to be sucked into the vessel. (Treves.) When air-embolism does not result fatally at once, no symptoms may develop. In a few cases a temporary paralysis has been observed.

Asphyxia may develop at any time during the operation, especially when there is a scabbard-shaped trachea. A surgeon should always be prepared to meet this emergency. Dyspnœa is often marked in the early stages of anæsthesia because the goitre is pressed against the trachea by the contraction of muscle. When anæsthesia is more complete, this condition is less marked. In other cases there is danger of having the trachea collapse or become kinked on trying to deliver the mass through the skin-incision. Tracheotomy is a grave complication because of the danger of infecting the wound, and should only be adopted as a last resort. An attempt should always be made to obstruct respiration as little as possible. Rapid operating, changing the position of the head, and elevation of the entire goitre may aid in this direction. Collapse of the trachea will be avoided effectually by the use of Kocher's suture above mentioned, or by leaving portions of the goitre which tend to support the tube. (Mikulicz.) Before the goitre has been delivered through the wound tracheotomy may be very difficult, and respiration much interfered with until this stage of the operation has been reached.

The œsophagus has at times been injured during the operation and closed by suture without disastrous result. (Hochgesand, Kappeler.)

Whenever an opening of the œsophagus appears secondarily, death is liable to result. All cases of this sort have died from infection.

Injury to the pleura has been reported giving rise to pneumothorax or to emphysema of the mediastinum.

The recurrent laryngeal nerve is especially exposed to injury on account of its position in the neck. The nerve has been completely divided or torn, or included in ligatures. The same may result from rough handling and the use of concentrated antiseptic solutions. It can only be determined that the injury to the laryngeal nerve took place at the time of operation if a laryngoscopic examination was made before and after interference. A paralysis may have existed before the operation that did not become evident until afterward. Of 23 cases of paralysis of the larynx observed by Wölfler, only 7 could be traced definitely to injury of the recurrent nerve. Jankowski's statistics show that division of this nerve is not uncommon, because alterations in the voice have been reported in 14 per cent. of the cases. In 2 per cent. the nerve was known to have been divided. Other authors report much higher figures. This complication has become less frequent since the modern improvements in technic. Kocher observed alterations in the voice after operation in only 7 per cent. of 1000 cases, and in benign goitres these symptoms disappeared almost entirely in most of the cases. Division of the nerve leads to aphonia if it is not compensated by increased activity of the other vocal cord. Laryngoscopic examination will show that one cord does not move, and in some cases paralytic contractures have been observed. Division of both nerves has been followed by permanent loss of voice, and death due to deglutition pneumonia has been reported. When the recurrent nerve is included in a ligature, symptoms of irritation arise, such as spasm of the cord, followed later by paralysis. This paralysis may be absent when the nerve has been only temporarily damaged by pressure or traction or some chemical irritant (carbolic acid). Should it have been already paretic, due to pressure from the goitre, any slight damage at the time of operation may result in complete paralysis. Paralysis that has existed before operation may in certain cases partially disappear. Traction upon the recurrent nerve may give rise to distinct shock, as observed by Wölfler in 2 cases. Injury to the superior laryngeal nerve is not quite so disastrous. It is doubtful whether the anæsthesia of the laryngeal mucous membrane favors aspiration pneumonia or not. The vagus is injured only in malignant tumors, and unilateral resection may give rise to no symptoms whatever. (H. Braun.) Injuries of the sympathetic nerve are not dangerous, as shown by the recent operations upon this trunk in morbus Basedowii.

Infection is the most important complication as regards the subsequent course of the wound. The germs enter from dirty instruments or bandages at the time of operation or whenever the dressing is changed in the after-treatment. Rarely, injury of the trachea or œsophagus is the cause of infection. There is no especial difference as regards the course than with infection in any other part of the body, except that the development of purulent mediastinitis must be remembered.

The rise in temperature due to infection must be distinguished from that which follows almost every operation for goitre. Only about 10 per cent. of the patients escape this post-operative hyperthermia. (Bergeat, Reinbach.) It seems to be due to the absorption of glandular elements, ferments or albumoses, that enter the circulation at the time of operation, or later from the cavities in the wound. A temperature due to infection differs clinically from this because in the latter there is no disturbance of the general condition, the patient feels perfectly well, breathing is normal, and the wound looks clean. Difficulties with breathing may develop during the convalescence. The most common cause is too tight bandages or too firm packing. Sometimes a hæmatoma of considerable size may give rise to pressure-symptoms, or dyspnœa may be due to accumulation of saliva which cannot be swallowed on account of post-operative paralysis of the œsophagus. Secondary collapse of the trachea, due to careless moving of the head, is much more serious. The adhesions between the skin and trachea usually keep the latter open, although at times they may favor kinking of the relaxed tube.

Pneumonia may be a symptom of sepsis, but in most cases it is due to aspiration. Its occurrence is favored by paralysis of the larynx after injuries to the recurrent nerve, because aspiration of infected bits of mucus from the mouth is not prevented. Patients with tracheotomy-wounds are exposed to the same danger. The danger of infecting the wound is increased, and the possibility of having injurious material enter the trachea is favored. Pneumonia in patients advanced in years is almost always associated with an unfavorable prognosis. More youthful individuals, whose circulation and respiratory organs have not suffered from long-continued goitre, at times survive this complication. The difficulty in swallowing, which develops almost always during the first few days after operation, disappears within a short time. It may, however, favor the development of pneumonia in the manner above described.

Post-operative Tetany and Chronic Operative Myxœdema.—There remains to be considered one more danger associated with operations upon goitre. This consists in the appearance of the acute and chronic symptoms due to removal of the organ. They were formerly divided into two groups: tetany and cachexia. At the present time it is known that these are identical as far as their etiology is concerned, and that one condition often develops into the other.

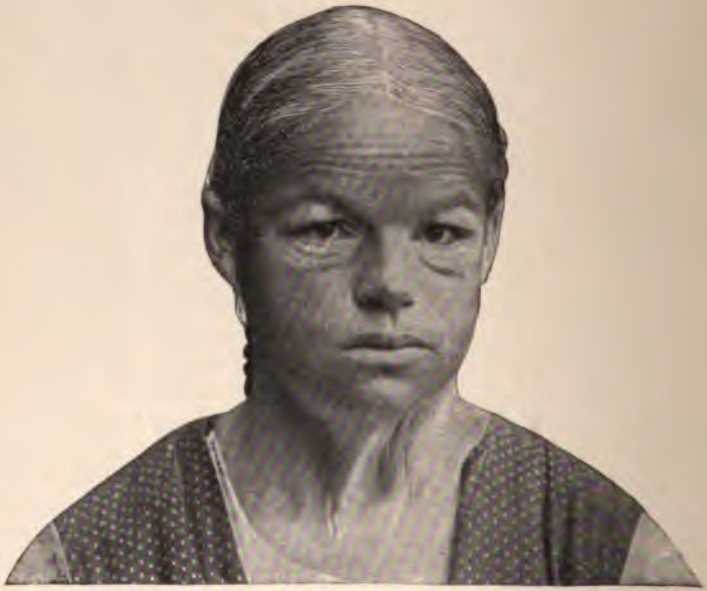
I. Post-operative acute myxœdema. This condition is extremely rare because total excision is no longer performed. Twelve cases were reported in Billroth's clinic up to 1890. The condition manifests itself by spasmodic attacks resembling tetanus, which not only affect the extremities, but also the muscles of the larynx and diaphragm, and may result fatally. The symptoms appear either immediately as soon as the patient comes out of the anæsthetic, or they develop several days after the operation (up to ten days). There are generally prodromal symptoms, such as a sense of nausea, stiffness, and weakness of the muscles of the forearm and calf. A diagnosis can frequently be made even before the attack from some statement made by the patient or by observing Chvostek's or Trousseau's phenomenon. The former is a lightning-like contraction of the side of the face following a sharp tap in the region of the corresponding facial nerve. The second is that pressure upon an artery or one of the larger nerve-trunks produces a spasmodic contraction of the corresponding extremity. The attack itself commences with cramps in the calf of the leg or as a stiff sensation of the face. In mild cases there are only tonic contractions of the upper extremities, especially of the forearm. The arm is slightly flexed at the elbow- and wrist-joints, and the hand flexed to the ulnar side, resting in the lap of the patient. The terminal phalanges are extended, the proximal phalanges flexed. The thumb is held in the hollow of the hand. In rare cases all the fingers are extended and separated, or all are flexed to make a fist. The muscles of the forearm are contracted and feel hard as bone. In severe cases the backs of the hands are approximated and the contraction affects the lower extremities. The hip-joint and knee are extended. The foot and toes are in plantar flexion. The contracted muscles of the face and extremities give rise to pain. The pulse is increased in rate. The temperature is only rarely increased and the sensorium is not clouded. The duration of the individual attacks varies from two to fifteen minutes. They recur several times a day with varying intensity. The milder cases may increase and present the picture of very severe tetany. The duration and number of the individual attacks increase progressively, while early or late appearance of symptoms does not indicate in any way the severity of the attack. Certain attacks may continue for several days. In this case the tonic contractions of the muscles of the face and of the other striated muscles of the abdomen and back may be easily observed. Spasm of the diaphragm usually leads to almost complete cessation of respiration. Contraction of the muscles of the neck increases the intense cyanosis by pressing upon the jugular veins. Unconsciousness supervenes, and death takes place a few hours after the attack has reached its height and has commenced to diminish.

Autopsies have never revealed any lesion of the nervous system, although complete absence of the thyroid gland or of accessory glands is almost constant. Usually the wound shows no local reaction or may be completely healed. A fatal result is the usual outcome. Of the 12 cases reported in Billroth's clinic, 8 died. Occasionally the disease disappears spontaneously (2 of 12) or changes to the chronic variety (2 of 12).

Tetany has even been observed after partial excisions, although in a somewhat milder form. The intensity of the symptoms seems to increase with the size of the resected portion of the thyroid gland. In some cases it appeared as if a large portion of the gland remained behind, but this was later shown to be incapable of function, because its physiological activity had been lost owing to malignant infiltration or due to injuries at the time of operation which affected its nutrition. The symptoms arising after ligation of all four arteries are to be explained by disturbances of nutrition.

Pronounced tetany may disappear in certain cases, and a distinct increase of the remaining portion of the thyroid gland has been observed at times. It would seem reasonable to assume that the tetany has been removed by regenerative processes in the remaining portion of the tissue. The function of the thyroid may not only be destroyed by the surgeon but also by the development of malignant tumors or by inflammation.

FIG. 117.



Circumscribed strumipriva in a woman aged twenty-six years. (v. Bruns.)

II. Aside from the acute symptoms appearing after complete removal of the thyroid, chronic conditions which are equally grave may develop in the course of months or after an acute attack. Chronic post-operative myxœdema (cachexia strumipriva, myxœdème opératoire) was discovered by Reverdin and Kocher. The acute attacks already described were more accurately observed after this author's investigations upon the chronic variety.

The chief symptoms of this condition are diminished mental activity, intelligence, and energy, and œdematous swelling of the skin. In youthful individuals there is in addition defective development. Patients have sometimes been perfectly well for months or even years after the operation, and have presented only slight symptoms of tetany. The disease gradually develops and finally reaches its height. The chief symptom of psychic disturbance consists in lack of energy and in mental apathy. Later there are signs of defective intelligence, especially impaired memory, and finally the patient becomes absolutely stupid and can be aroused only for a short time. His motions are slow and awkward and the acuteness of his senses is diminished.

The changes in the skin render a diagnosis quite easy. The face is waxy white and thickened, although dry, because of the absence of perspiration or secretion from the sebaceous glands. The hair becomes colorless or falls out entirely. The lower lids are œdematous and hang down. Power to mimic is lost. The changes in the lines of the face increase the expression of apathy. The œdema, which differs from that of congestion by the absence of pitting on pressure, may extend to the skin of the extremities and trunk. Masses develop over the clavicles resembling lipomata. The mucous membranes of the mouth and gums may be attacked, so that talking is difficult. The amount of hæmoglobin is diminished and there is a slight leucocytosis. The growth of the long bones in youthful individuals is interfered with (v. Bruns), although the width of the individual bones is normal. The anatomical condition at the epiphyses is the same as in cretins. Puberty is retarded or never develops. The patients always complain of a sense of chilliness. They like a warm room and keep close to the stove. All these symptoms are not always present at the same time. There are milder cases in which the condition is barely indicated. Sometimes the disease will improve if a secondary thyroid (v. Bruns, Kappeler) or a remnant of thyroid gland (Reverdin, Bassini) undergoes compensatory enlargement, or when medical treatment is effective.

Myxœdema has been observed after partial excision of goitres just as in the case of tetany. The clinical picture is usually correspondingly less marked. Sometimes this disease has developed secondarily to chronic processes in the thyroid gland (actinomycosis, carcinoma), which diminish the quantity of gland-tissue capable of physiological function, or may even destroy the entire gland. According to reports, only a certain number of the patients with total excision of the gland are said to suffer from myxœdema, and the London Myxœdema Committee stated that this occurred in only 24 per cent. of 227 cases of total excision. This percentage is so small, and is so at variance with the experience of other authors, that it seems justifiable to assume that the total excisions were only partial in many cases, or that the number of recurrent goitres reported, which was said to be 8 per cent., is too few. The position of recurrent goitres and accessory thyroid glands often removes them completely from observation. The short period of observation after operation is probably the reason why many cases that subsequently developed symptoms did not appear in the above statistics.

Kocher reports 24 cases of cachexia (70 per cent.) following 34 as regards the course than with infection in any other part of the body, except that the development of purulent mediastinitis must be remembered.

The rise in temperature due to infection must be distinguished from that which follows almost every operation for goitre. Only about 10 per cent. of the patients escape this post-operative hyperthermia. (Bergeat, Reinbach.) It seems to be due to the absorption of glandular elements, ferments or albumoses, that enter the circulation at the time of operation, or later from the cavities in the wound. A temperature due to infection differs clinically from this because in the latter there is no disturbance of the general condition, the patient feels perfectly well, breathing is normal, and the wound looks clean. Difficulties with breathing may develop during the convalescence. The most common cause is too tight bandages or too firm packing. Sometimes a hæmatoma of considerable size may give rise to pressure-symptoms, or dyspnœa may be due to accumulation of saliva which cannot be swallowed on account of post-operative paralysis of the œsophagus. Secondary collapse of the trachea, due to careless moving of the head, is much more serious. The adhesions between the skin and trachea usually keep the latter open, although at times they may favor kinking of the relaxed tube.

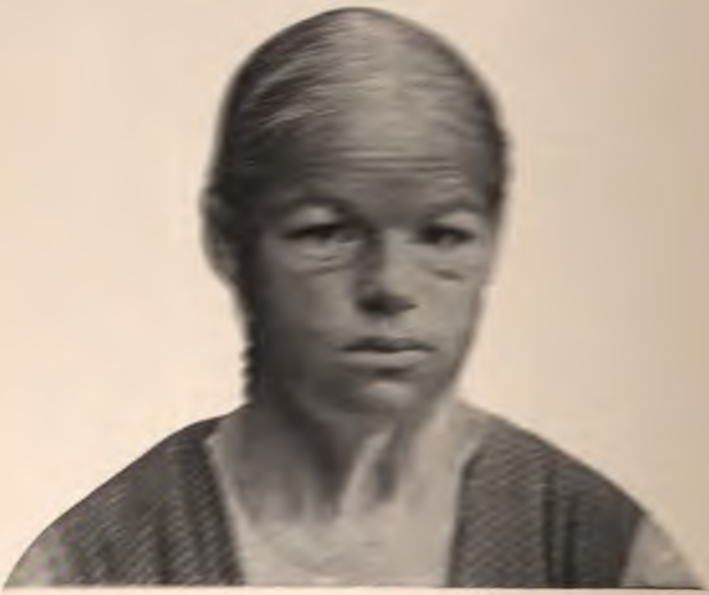
Pneumonia may be a symptom of sepsis, but in most cases it is due to aspiration. Its occurrence is favored by paralysis of the larynx after injuries to the recurrent nerve, because aspiration of infected bits of mucus from the mouth is not prevented. Patients with tracheotomy-wounds are exposed to the same danger. The danger of infecting the wound is increased, and the possibility of having injurious material enter the trachea is favored. Pneumonia in patients advanced in years is almost always associated with an unfavorable prognosis. More youthful individuals, whose circulation and respiratory organs have not suffered from long-continued goitre, at times survive this complication. The difficulty in swallowing, which develops almost always during the first few days after operation, disappears within a short time. It may, however, favor the development of pneumonia in the manner above described.

Post-operative Tetany and Chronic Operative Myxœdema.—There remains to be considered one more danger associated with operations upon goitre. This consists in the appearance of the acute and chronic symptoms due to removal of the organ. They were formerly divided into two groups: tetany and cachexia. At the present time it is known that these are identical as far as their etiology is concerned, and that one condition often develops into the other.

I. Post-operative acute myxœdema. This condition is extremely rare because total excision is no longer performed. Twelve cases were reported in Billroth's clinic up to 1890. The condition manifests itself by spasmodic attacks resembling tetanus, which not only affect the extremities, but also the muscles of the larynx and diaphragm, and may result fatally. The symptoms appear either immediately as soon increase with the size of the removed portion of the thyroid gland. In some cases it appeared as if a large portion of the gland remained behind, but this was later shown to be incapable of function, because its physiological activity had been lost owing to malignant degeneration or due to ligation at the time of operation which affected its nutrition. The symptoms arising after ligation of all four arteries are to be explained by disturbances of nutrition.

Recurrent tetany may disappear in certain cases, and a distinct increase of the remaining portion of the thyroid gland has been observed at times. It would seem reasonable to assume that the tetany has been removed by regenerative processes in the remaining portion of the tissue. The function of the thyroid may not only be destroyed by the surgeon but also by the development of malignant tumors or by inflammation.

FIG. [illegible].



Circumscribed strumipriva in a woman aged twenty-six years. (v. Bruns.)

II. Aside from the acute symptoms appearing after complete removal of the thyroid, chronic conditions which are equally grave may develop in the course of months or after an acute attack. Chronic post-operative myxœdema (*cachexia strumipriva, myxœdème opératoire*) was discovered by Reverdin and Kocher. The acute attacks already described were more accurately observed after this author's investigations upon the chronic variety.

The chief symptoms of this condition are diminished mental activity, intelligence, and energy, and œdematous swelling of the skin. In youthful individuals there is in addition defective development. Patients total excisions; Garrè reports 50 per cent. of post-operative myxœdema in 67 cases. Of 52 cases of total excision performed in Billroth's clinic up to July, 1892, Wölfler and the author were able to follow the fate of 37: 12 of these developed tetany, 9 resulted fatally, 11 showed signs of myxœdema (3 of these had recurrent goitre); 10 remained well, and 3 of these showed no signs of any accessory goitre. In 1 patient the cachexia present before operation remained unchanged, and 3 died after operation. It will be seen that 23 patients out of 33 total excisions developed subsequent symptoms which were partly acute and partly chronic. In 70 per cent. of the cases therefore the dreaded secondary symptoms developed. Kocher has reported later cases in which cachexia developed after all total excisions with the exception of 1 case in which a recurrence could be demonstrated. In 900 partial operations only 1 case was observed (malignant).

Clinical observation corroborates the author's view regarding the value of the thyroid gland in the human economy. The results of experiments on animals correspond also closely to the clinical conditions. It need not be emphasized that the operation itself or disturbances in the wound do not give rise to tetany or myxœdema. In cases of myxœdema or tetany after partial removal of the thyroid gland the quality or quantity of the remaining portion has not been sufficient to perform the normal function of the gland. These cases, which at first do not seem to correspond with modern views, on more careful examination will be seen to corroborate current ideas, because they show that the severity of the symptoms diminishes in inverse proportion to the amount of gland-tissue left behind.

In animals after total excision of the gland tetany has been at times observed to change to chronic cachexia. One is justified in believing that the etiology of both conditions is the same, although it is not known why secondary symptoms develop in one case immediately, whereas in another they appear only months after operation. Wölfler considers the differences in individuals and races and localities to be the cause of this irregularity in the clinical picture. It is notable that in regions where goitre is not common (Billroth's Vienna cases) tetany usually supervenes, whereas in regions where goitre is endemic, myxœdema usually follows. (Kocher.) Perhaps people who live in regions where goitre is endemic may have become accustomed through generations to a diminished function of the thyroid gland and can withstand better its sudden removal. In youthful patients and during pregnancy the symptoms following removal are usually much more violent, because it would seem that at these times there is increased demand upon the thyroid gland. The animal experiments of Halsted and M. Lange corroborate this view. External conditions, differences in the method of feeding and in the method of operating, whether intracapsular (Billroth) or extracapsular, (Kocher), may play some part.

Treatment of Tetany and Cachexia after Excision of the Thyroid Gland.—The fact that the symptoms developing after complete removal may be avoided by leaving a certain quantity of thyroid tissue behind, and that pronounced tetany or cachexia may diminish with an increase of the gland remaining, indicates the path which must be followed to obtain the desired results from treatment. Organotherapy has been very successful, whereas other methods of treatment have been devoid of results. Transplantation of the thyroid gland, or injection with thyroid, or internal administration of thyroid gland-tissue has been followed by brilliant cures.

Kocher was first (1883) to transplant thyroid gland-tissue into a cachectic patient after taking the observations of Schiff into account. In this case the gland became atrophied and the cachexia continued. Six years later Bircher transplanted intraperitoneally an excised portion of the thyroid in a girl with severe cachexia and obtained a definite although temporary result. Later similar experiments were made by transplanting human or animal thyroid tissue in the effort to cure the cachexia. (Horsley, Wölfler.) Often there was no result because the transplanted portion of gland became necrotic. This method of treatment was abandoned because a more reliable and less fatal method was discovered. The injection treatment tried on animals by Vassalle and by Murray on human beings in genuine cases of myxœdema, and latter in cachexia, won many advocates on account of its simplicity and lack of danger. This was supplanted by the still less objectionable treatment of feeding with fresh or dried thyroid gland-tissue. (Kocher, Leichtenstern, C. A. Ewald.) The cases that have been favorably influenced by internal administration of thyroid gland are so numerous that it seems possible to express some opinion relative to the value of this method. Not only symptoms of short duration, but even those that had persisted as many as nine or more years, have been completely removed by this treatment. The gland is used in exactly the same way as in genuine myxœdema. In spite of these favorable results prophylactic measures should not be disregarded. Total excision of the gland should never be performed. The possibility of virulent tetany can never be excluded. It appears at times when the entire organ is infiltrated by a carcinoma and any function seems impossible. In most cases a piece of gland-tissue the size of a hen's egg should be left, but if at the time of operation one is forced to remove more gland-tissue than seems advisable, thyroid should be given immediately whenever the slightest secondary symptoms appear, and should be continued for a considerable time. It is well at first to restrict the amount of meat taken by the patient.

LIGATION OF THE THYROID ARTERY, TRANSPLANTATION OF GOITRE, AND EXOTHYROPEXY.—Here will be considered briefly two methods of operation which endeavor to preserve the entire thyroid gland and yet allay the symptoms of goitre. These are ligation of arteries and exothyropexy.

Although ligation of the thyroid arteries was anciently practised, it was never considered justifiable to make use of this method before the antiseptic era on account of the danger of infection, and it was finally abandoned as a dangerous procedure. Wölfler rescued the operation from oblivion and tied both arteries on one side with success. Later observations collected by Rydygier showed that this operation might be justifiable in parenchymatous goitres where there was no degenerative change, as in the rapidly developing goitres of youthful individuals. In malignant tumors and cystic goitres, in fibrous or calcareous goitres, this method was productive of no results. All four arteries must be tied at one operation. The result appears usually soon after operation, and consists in death of the larger part of the thyroid gland on account of interference with its nutrition. This method, however, is frequently associated with recurrences, and as it is almost, if not quite as difficult as partial excision or enucleation, it is made use of only in vascular cases.

The technic of the operation has been especially developed by C. M. Langenbeck. Ligation of the superior thyroid is simple. An incision is made along the inner margin of the sternomastoid close beneath the hyoid bone. After division of the platysma the sternomastoid is pulled outward, the omohyoid retracted inward, and the upper margin of the gland exposed in the wound. The artery is isolated and tied. Ligation of the lower vessel is much more difficult. A curved incision is made along the lateral margin of the sternomastoid. This muscle, the large vessels, and nerves are retracted toward the median line and the anterior scalenus muscle sought for, which may be recognized by the phrenic nerve crossing its anterior surface. The artery will be found running diagonally upward and inward at the median margin of this muscle after lifting the external portion of the goitre. In tying this vessel one should remember that its walls are very delicate, and not forget the proximity of the recurrent nerve. Kocher follows Velpeau's method of tying. The skin-incision is made along the inner margin of the sternomastoid and carried down to the capsule of the goitre. The gland is retracted inward and the artery running crosswise will be exposed in the wound. Bonnet's method of dislocating the goitre has recently been applied by Wölfler in a case of retrosternal enlargement. After exposing by blunt dissection the portion of the goitre in question, silk ligatures are passed through the mass, then through the muscle and skin, and tied outside, so that the gland is supported by the thread. This method has given relief in some cases.

Exothyropexy (Jaboulay, Poncet, Bérard) consists in delivering the goitre through the skin-incision and leaving it in place. The symptoms of pressure are said to be alleviated in this way, and the goitre is supposed to disappear gradually on account of secondary contraction. The skin and fascia are divided in the median line. The muscles are retracted to either side. The goitre is loosened and delivered through the wound, interfering as little as possible in the region of the vessels. The latter step in the operation must be done with care on account of the danger of tearing the veins and of sudden interference with respiration due to kinking of the trachea. An aseptic dry dressing is placed over the dislocated goitre.

During the first few days there will be a rise in temperature and profuse secretion of a lymph-like fluid (goitre sweats.) This rise in temperature has been explained by resorption of thyroid secretion, because it is said to be absent when the dislocated goitre is tied off around its hilus. Contraction takes place gradually, the goitre becomes nodular, and small cysts appear, so that the mass resembles a bunch of grapes. This diminution in size progresses until after two weeks to two months nothing but a fibrous mass is left. The margins of the wound approximate so quickly during this process that it is at times necessary to free them repeatedly so as to allow contraction to progress by renewed exposure of the goitre.

Although this operation is simple technically, a series of complications may arise. Four fatal cases have been reported out of 65 cases. One of these deaths took place on the day after operation, associated with typical signs of tetany. The most frequent complication is infection of the goitre. Suppuration may be slight, but may persist for months, and may be followed by fatal secondary hemorrhage. For the purpose of avoiding this danger the mass has either been exposed for only a few hours at a time or only sufficiently to allow the air to come in contact with its surface. When this method proves insufficient, then the mass must be treated as above or enucleated by a second operation. Dyspnœa, palpitation, or pneumonia, due to bilateral paralysis of the recurrent laryngeal nerves, have also been observed. This method of treatment may be devoid of any beneficial result on account of insufficient contraction of the goitre and rapid closure of the skin-wound, and inasmuch as it is not without danger, Lanz's statement that it is meddlesome surgery is not unjustifiable.

TRACHEOTOMY IN GOITRE.—Tracheotomy is only a palliative way of treating goitre. It has been mentioned that it should be avoided if possible on account of the danger of infecting the wound and on account of pneumonia. Only with severe dyspnœa that cannot be relieved by an immediate operation should this step be considered. It may be impossible to follow the general rule to open the trachea below the seat of obstruction because difficulties may arise that cannot be overcome in cases of retrosternal goitre. A tracheotomy-tube must be inserted above the seat of constriction in these cases and a long elastic tube (König) passed through the obstruction if possible. Sometimes this method leads to pressure-ulcers in the trachea with subsequent œdema and swelling of the tracheal mucous membrane, and may not only increase the danger from pneumonia in this way, but also favor death from suffocation.

This operation in goitre is one of the most difficult varieties of tracheotomy;—one of the most difficult of operations at times. If possible, the patient should be anæsthetized. A long skin-incision and accurate hæmostasis will facilitate the procedure. When it is not possible to see the trachea, it should be sought for with a finger, and is recognized by the rings of cartilage, which can usually be felt even when the trachea is scabbard-shaped. In cases of carcinoma the trachea may be so completely surrounded by masses of tumor that only the thyroid notch gives any idea of its position. Whenever the trachea is flattened anteroposteriorly, care must be taken not to open the posterior wall at the same time. Either Salzer's canula with a movable shield, or a canula with an elastic inner tube and a long fixation apparatus, should be used. The deeper the seat of the stricture and the longer this operation is deferred, the more unfavorable the prognosis. Patients that have recovered from repeated attacks of suffocation may not survive even when the entrance of air is unobstructed.

Treatment of Cystic Goitre.—The treatment of cystic goitre demands especial description. The symptoms have been emphasized in connection with the remarks on diagnosis. It has been shown that the cysts of goitre are oftentimes the largest tumors observed, and that they may produce symptoms of pressure upon the trachea when growing rapidly, or may disappear spontaneously by gradual contraction. The methods of treatment may be subdivided into palliative and radical. The former is seldom employed at the present time. There are only a few cases reported in which recovery took place after simple incision or puncture. This treatment is advocated now only when the pressure must be removed from the trachea immediately.

Attempts have been made to produce contraction by injecting irritating fluids. Diluted tincture of iodine or pure iodine seemed to be most effective. Billroth injected from 5 to 7½ fluidrachms. A cure was effected in 67 per cent. of the cases. Not infrequently there are violent symptoms of reaction, rapid swelling of the cysts with dyspnœa, and a sharp rise in temperature. Inasmuch as recovery is very slow and a cure does not result when the cyst-wall is dense, and as recurrences are common, and especially because of the danger of fatal collapse (when veins communicate with the cyst), the injection of iodine has been restricted to a few cases only. The mortality of this method, apparently so harmless, is about 2 per cent. It is absolutely counterindicated in multilocular cysts or in those with bloody or tenacious contents, and whenever there is paralysis of the vocal cords. Nevertheless, should injection treatment be preferred, then iodoform oil and ether mixtures are preferable. Draining the cyst with strands of hair or rubber drains has been abandoned. Splitting the cyst and subsequent packing are not associated with such great danger of infection. The results of this treatment are not good, because a certain amount of suppuration is necessary for a cure. In old individuals this method of treating cysts is still associated with the least amount of danger, and for this reason the technic is described. After exposing the cyst the wall is opened with a cautery and hemorrhage checked with the utmost care. This may be quite difficult at times. The contents are carefully removed and the cavity packed loosely with gauze, a drain inserted, and the wound partially closed. Recovery does not always take place. An endeavor has been made to favor this by sewing the margin of the sac into the wound (Chelius) after excising an elliptical portion of the capsule. Intraglandular removal of cysts is the best method of treatment, because it is much easier than shelling out goitre nodules, for the cysts are usually covered only by a thin cortical layer of gland-tissue that seldom bleeds when divided. When the cysts have firm walls that are closely adherent, there may be difficulty in removing the tumor. The technic is similar to that of enucleation. With multiple cysts enucleation is the only method to be used. However, in retrosternal cysts and those extremely adherent it cannot be employed. Excision must be done at times in these cases. Danger of pyæmic infection is a counter-indication to the enucleation of inflamed or suppurating cysts.

The results of operation are excellent. Of 66 enucleated cysts, 65 cures and 1 death (purulent cyst) were reported by Wölfler. Enucleation is to be considered the normal method of operation in cystic goitres. In adherent old cysts excision must be done, and in run-down patients or whenever there is suppuration incision and drainage should be practised.

CHAPTER VIII.

INJURIES OF THE THYROID GLAND AND OF GOITRES.

It does not seem appropriate to distinguish between injuries of the thyroid gland itself and those of goitres, because the etiology, the symptoms, and the treatment are the same in both cases. It is evident that injuries of a goitre will be much more common than those of a normal gland. These injuries may be subdivided into subcutaneous and compound, and the latter into stab-, incised, lacerated, and shot-wounds. They follow attempts at suicide, and are of secondary interest because of the injuries of the trachea and of the large vessels of the neck. Incised wounds are most common in operations for goitre, especially since it has become customary not to excise the gland *in toto*. In these cases the hemorrhage should be arrested by tying, cauterization, and packing. In gunshot-wounds it may at times be necessary to enlarge the opening for the purpose of checking the hemorrhage.

INFLAMMATIONS OF THE NORMAL THYROID GLAND AND OF GOITRE.

The resemblance of inflammation of the thyroid gland and of goitre is so great that both processes will be considered together. Goitre, of course, as in cases of injury, will be far more frequently affected than the normal gland. (Lebert, Kocher.) Follicular and cystic goitres are especially prone to inflammation.

It is necessary to distinguish between predisposing and etiological factors of inflammation. To the former belong contusions and any congestion (pregnancy, carrying of weights). It has not been proved whether "catching cold" should be included in this group or not. The real cause is either direct injury (with subsequent infection) or some general infection of the patient which is followed by metastases in the thyroid. This metastatic thyroiditis or strumitis may develop in the course of typhoid, pyæmia, puerperal fever, pneumonia, scarlet fever, variola, diphtheria, malaria, and in articular rheumatism. Even simple constipation may be followed by suppurative metastases in goitre. (This has been demonstrated by Brunner and Tavel, who found *Bacilli coli communis* in the abscesses.)

The symptoms are those of acute inflammation in general; pain, swelling, fever, and redness if the abscess is superficial and threatens to rupture externally. These symptoms may be severe when the rapidly growing mass presses upon the trachea or the nerves of the neck, and there may be marked difficulty in breathing and swallowing. The result is disintegration, suppuration, and necrosis. Disintegration is not common. When pus is present, it may perforate externally and spontaneous recovery follow. Perforation of the trachea and œsophagus may, however, take place, and in the former case death from suffocation is liable to result. Dangerous infiltration of deeper seated tissues with pus has also been observed. In a case observed by Kerns the abscess extended toward the floor of the mouth; and Lejars reports a case of erosion of the carotid by a suppurating cyst of the thyroid. When there is gangrene of a portion of the thyroid gland, the symptoms of sepsis are more intense. Spontaneous perforation externally may be followed by the discharge of necrotic gland-tissue. The treatment at first consists in the application of poultices and rest. When pus is present, which will be indicated by the general condition of the patient and the local signs, free drainage should be furnished. Open incision with subsequent packing of the wound is much better than aspiration and injecting antiseptics. When all foci of infection have been opened and the inflammation is not too extensive, complete recovery is to be expected.

The author observed tetany continuing until death in acute suppuration of the thyroid gland. A similar observation has been reported by Kocher following removal of one-half of a goitre for suppuration. The autopsy showed that the other half of the goitre contained pus.

Kummer and Kocher have recently recommended removal of the suppurating half of the thyroid gland in the treatment of strumitis suppurativa.

In most cases of thyroiditis the diagnosis is easy, although there are certain types difficult to recognize. Riedel and Tailhefer have described a slowly progressing inflammation of the thyroid giving rise to firm, board-like induration of the gland without causing suppuration. This type of goitre is closely adherent to the large vessels of the neck. The differential diagnosis between this and malignant goitre (scirrhus) is difficult. The suspicion of malignant growth is supported by the fact that microscopical examinations have shown no epithelial elements. It is well known that at times it is difficult to demonstrate these elements in a scirrhus. Riedel reported improvement after partial excision in his cases, and the author recollects a case of this sort in Billroth's clinic in which the entire brawny infiltration disappeared after partial excision. Clinically this case was supposed to be a scirrhus, but microscopical examination showed only fibrous tissue with few cells.

Infective Inflammations of the Thyroid Gland.

Tuberculosis.—Two varieties of tuberculosis are found in the thyroid gland. In one form the thyroid gland is infiltrated with miliary tubercles. It is part of the general condition in miliary tuberculosis. (Virchow, Cornil, Ranvier, Cohnheim, Chiari, E. Fränkel.) In the other form there are tuberculous nodules in the goitre that may cause pain and difficulty in breathing, and may be confounded with other varieties of goitre. In a case reported by v. Bruns there were paralysis of the recurrent nerve and infiltration of the surrounding lymph-glands on the affected side, so that a malignant growth seemed present. Examination of the excised tumor explained the nature of the disease. The patient returned after four months with tuberculous glands of the neck. Schwartz has reported a similar case which he operated upon.

Actinomycosis.—Köhler has reported a case of this sort which gave rise to myxœdema.

Lues.—In recent cases of syphilis the gland is sometimes found swollen, in sympathy with the infiltration of the lymphatic glands. (Engel-Reimers, Mauriac, Jullien.) This swelling is permanent in only a limited number of cases. The type which interests the surgeon most occurs in tertiary syphilis or in hereditary lues, and may involve the entire gland and give rise to myxœdema. (Köhler.) Gummatous infiltration is most common (v. Bruns), the rapid growth of which (dyspnœa, paralysis of the recurrent nerve, and pain) may lead one to suspect a malignant new growth, especially as the lymph-glands are considerably swollen (Küttner). In the case observed in v. Bruns' clinic the prompt action of iodides enabled a diagnosis between syphilis and cancer or tuberculosis. In cases in which there may be suspicion of syphilis the administration of iodides is appropriate.

ECHINOCOCCUS OF THE THYROID.

This condition is extremely rare. According to Henle and Vitrac, only 20 cases have been reported, to which may be added the case recently operated upon by the author. Goitre does not seem to be a predisposing element in this affection.

Infection may take place through the circulation, and perhaps directly through a wound. (Meinert.) In the early stages there are few symptoms, although later they may become extremely annoying. Dyspnœa develops early on account of the adhesions to the surrounding tissues. It will be more marked than the interference with respiration produced by a cystic goitre of the same size. Hydatid "Schwirren" or repeated urticaria with diminution in the size of the cyst will make the diagnosis easy, although these symptoms are rarely present. The diagnosis has as yet never been made before operation or before an exploratory puncture had been performed.

An operation is positively indicated, because fatal perforation of the trachea results comparatively early (of 18 patients, 4 died in this way, although the cyst was no larger than an orange). The author agrees with Henle that free incision is the best way of treating the condition, although enucleation may be performed with success. Injection of antiseptics and unilateral excision are less reliable.

NEW GROWTHS IN THE THYROID.

Benign tumors of the thyroid are extremely rare if the above-mentioned adenomata are not included. Fibromata and lipomata are uncommon. Malignant tumors, on the other hand, are comparatively frequent. Sarcoma and carcinoma develop usually in a thyroid gland that is affected by goitre. It has not been definitely determined which variety of these tumors is more frequent, because the histological conditions of these growths are very difficult to distinguish when the thyroid gland is involved compared with similar disease in the rest of the body. Limacher, in Bern, found 44 sarcomata and 38 carcinomata of the thyroid gland in 7461 autopsies, which would seem to indicate that they are about equally common. Chiari, in Prague, found 11 carcinomata and 5 sarcomata in 7700 autopsies, which would seem to show predominance of carcinoma. Both varieties of tumor have a tendency to extend beyond the capsule of the thyroid and infiltrate the surrounding tissue. They give rise to difficulty in swallowing much more frequently than benign tumors. There is a distinct tendency to form metastases in the lung and the bones. Of the latter, those of the skull, the sternum, and ribs are most frequently involved.

Sarcoma of the thyroid usually develops in young individuals, grows rapidly, and is extremely malignant. The etiology of sarcoma of the thyroid gland is as little known as is that of its occurrence in other regions of the body. All known pathological varieties are met with. Spindle-cell and round-cell sarcoma, alveolar sarcoma, and endothelioma have been reported, and a few cases of melanosarcoma and osteosarcoma. The growth usually attacks but one lobe, and usually the right side. In rare cases the entire gland-tissue may be infiltrated so that a uniform enlargement is observed. There is usually sufficient gland-tissue left to prevent the appearance of symptoms secondary to total destruction. Pressure-symptoms referable to the trachea and œsophagus develop, and the veins and large nerve-trunks may be affected, leading in many cases to death. Sometimes the tumor involves the skin, which may be followed by hemorrhages and suppuration.

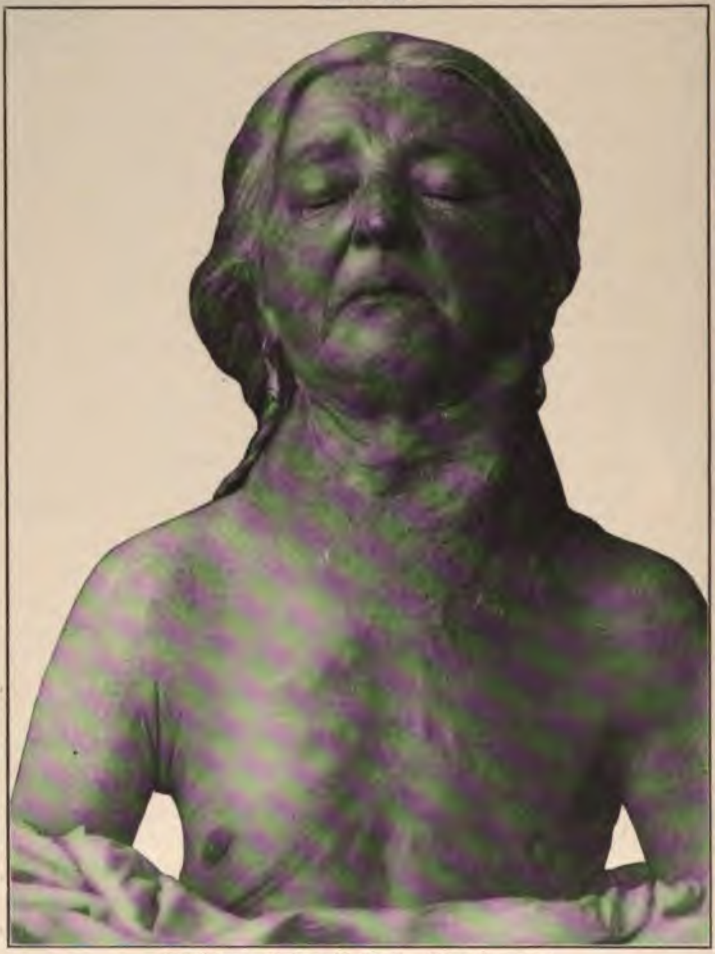
Operative interference may have hope of success when the surrounding tissues are not involved and no metastases have developed. The diagnosis, however, in these cases is difficult, and will be rendered probable only on account of the youth of the patient and the rapid development of the tumor. Exploratory incisions can be made without danger, provided excision is possible and can be performed immediately. In inoperable tumors, however, this may favor involvement of the skin.

Carcinoma of the thyroid gland is usually found in individuals more advanced in years, and appears most frequently in regions where goitre in endemic, especially in subjects who already suffer from a diseased gland. Individual cases have been reported occurring before thirty years of age (H. Braun, Wölfler), and even in childhood

(Demme). The most common variety is soft medullary carcinoma, which is classified with adenocarcinoma or alveolar carcinoma. Scirrhus and squamous epithelial carcinoma are more uncommon. The latter are probably due to remnants of branchial clefts.

Cancer may develop as an isolated nodule or involve the entire lobe or the entire gland. The size of the organ rapidly increases, although in scirrhus and malignant adenoma and medullary cancer this symptom may be absent at times. The capsule is involved early and secondary infiltration of the lymphatic glands and surrounding structures is then observed. This is soon followed by difficulty in swallowing and breathing, symptoms of pressure upon the veins (œdema) and nerves of the neck (neuralgia and paralysis). The metastatic growths

FIG. 118.



Carcinoma of thyroid gland. (Curschmann.)

correspond histologically to the primary tumor, but in rare cases they may closely resemble normal thyroid tissue. The duration varies. The growth may persist for years before cachexia or some local disturbance produced by the tumor (perforation, suppuration, or hemorrhage) leads to a fatal termination.

The course and development of metastases distinguish malignant adenoma (adenocarcinoma) from the other types of cancer. Sometimes it is impossible to demonstrate any deviation in structure histologically from normal thyroid gland-tissue, either in the gland itself, which may maintain its normal size, or in the metastases in the lung or osseous system. The malignant nature of the affection, however, is indicated by the metastases that develop. Kocher, Jr., found glycogen-containing portions in these metastatic adenomata.

Müller and Cohnheim were first to observe these adenomata, and classified them as a rare variety of benign tumors giving rise to metastases. They were supposed to develop in cases of adenoma of the thyroid on account of some peculiarity of the constitution. v. Recklinghausen showed that this view was not tenable. According to the value placed upon the histological picture and the presence of metastases in the diagnosis of tumors, different names have been applied by different authors—malignant (Wölfler) or adenocarcinoma (Kundrat)—even when the clinical picture is that of ordinary thyroid adenoma.

The metastases of adenocarcinoma present a special problem on account of their occasional presence within bone. Efforts have been made to remove them by operation when they gave rise to symptoms. Kraske and v. Bruns removed successfully a metastasis of this sort from the frontal bone, and Riedel one from the lower jaw. The growth of metastases is at times extremely slow. In 2 cases observed in Billroth's clinic they were the size of a fist after six and eight years. These bony metastases sometimes cause the patient to consult a physician even before disease of the thyroid is clinically evident. In regions where goitre is endemic tumors of the bones which resemble sarcoma should always lead to a suspicion of metastases of this sort. Carcinomatous or purely adenomatous primary tumors may be associated with cancerous or harmless metastases. (Jäger.) The metastases may at times present the typical picture of cylindrical carcinoma, yet they are capable of producing colloid, and may in individual cases perform the function of the excised or otherwise destroyed thyroid gland. The author observed after total excision of a thyroid gland, which on microscopical examination proved to be adenomatous, symptoms of cachexia strumipriva develop, which abated with the growth of a hard tumor within the sternum. Six years later it became necessary to excise this metastatic mass on account of the developing pressure-symptoms. Post-operative thyroid tetany occurred. The tumor of the sternum had performed the function of the thyroid gland, and had prevented the appearance of symptoms due to total removal of the organ, although it was shown to contain no thyroid tissue, but proved to be a cylindrical cell carcinoma with power of secreting colloid.

[illegible] in the course of the Aar in [illegible]. Further investigation [illegible] these diseases are not found [illegible] in the immediate vicinity of the Aar, where there is no question that the people [illegible] are these diseases common. The [illegible] between the [illegible] and the Aar is a region where goitre and cretinism are prevalent. On investigation it will almost always be found that parents of a cretin suffer from goitre or that the mother while pregnant or shortly after birth was in a vicinity where goitre was endemic. A child with cretin parents is especially disposed to cretinism.

Cretinism varies in its intensity, and is characterized by three cardinal symptoms: 1. Disturbances of growth, specific changes in the skin and undeveloped genitals. 2. Idiocy. 3. Enlargement or complete absence of the thyroid gland.

Disturbances of Growth in Cretins.—Changes in the long bones, the skin, and genitals are the chief signs of impaired growth.

At birth no sign of cretinism may be present. The symptoms develop later, and are manifested chiefly in changes affecting height, the width not being altered; changes in the growth of bone secondary to those of the cartilage. Cretins always have a plump, thick-set appearance. R. Wagner reports a cretin twenty-two years of age who was only 80 cm. tall. The individuals cease to develop, however, at a much later period than normal individuals, and have been observed to grow even after thirty years. The skull shows a depression at the root of the nose, so that the nose itself seems to be almost vertical to the glabella. The long bones are thick and short, and ossification takes place at the epiphyses quite late, as Langhans has shown by autopsy and Hofmeister by the x-rays. This condition corresponds to that observed in rabbits by Hofmeister, and in sheep by the author, whenever the thyroid gland was removed early in life. These bony changes differ markedly from those of rhachitis, although they resemble so closely the bones of so-called fetal rhachitis that these diseases have been considered identical. In dwarfs, as distinguished from cretins, the skeleton remains undeveloped in proportion.

The skin of cretins shows characteristic changes. It is thick, smooth, lax, and chalky in color. Sometimes it is oedematous, although it does not pit on pressure. In the supraclavicular fossa there is a pad-like thickening, the mucous membranes may be swollen, the skin is dry, scaly, and devoid of secretion. The nails and hair are brittle and fall out easily. Males have no beard and the teeth are often carious. The body temperature is frequently 1 to 2 degrees lower than normal.

The undeveloped condition of the genitals is a peculiarity of cretins; the penis and scrotum, the labia, and uterus remain as before puberty. The function of the genitals is undeveloped, although it is not uncommon to have sexual function restored even after thirty years, so that cretins have become pregnant at times. Fortunately typical cretins have no power of perpetuating their kind.

Alveolar tumors are much more common than adenocarcinomata, and may give rise to enormous growths (Fig. 119) or remain so small that the metastases direct attention to the primary tumor. The microscopical structure does not always remain purely alveolar, because at times cylinder-cell ducts are found mixed with the alveoli. Scirrhus is extremely uncommon. The gland is oftentimes contracted. One of. the most important symptoms of malignant tumors is therefore absent, and only the almost cartilage-like consistence and the presence of secondary tumors of the lymph-gland make the diagnosis probable. Microscopically the gland appears small and cracks on incision. Normal tissue or cancer foci are found only at the periphery. In the centre there are dense masses of tissue in which here and there disintegrated alveoli may be demonstrated microscopically. (Billroth.) The slow growth taking place at the periphery and the microscopical examination of the metastases make it evident that the process is not one of chronic inflammation. Scirrhus may give rise to severe symptoms of pressure upon the trachea and œsophagus on account of extension to these organs.

Diagnosis.—In the early stages the diagnosis may be difficult, although in advanced cases the clinical picture cannot be mistaken. In individuals advanced in years, who have had a goitre of moderate size for some time, which suddenly begins to increase in size and become much firmer, associated with swelling of the lymphatic glands and difficulty in breathing and swallowing, perhaps with pressure-symptoms referable to the nerves and vessels, the diagnosis will be evident. These patients often emaciate and become cachectic.

Prognosis.—The disease ceases spontaneously only in rare cases. Usually it progresses steadily. Operative treatment may give a radical cure only when the capsule has not been involved.

Treatment.—A surgeon generally removes the gland. When this has been done thyroid extract should be given immediately after the operation. Extensive resection of the larynx, the trachea, the œsophagus, the larger vessels and nerves has been performed in connection with operations for cancer of the thyroid gland. (Péan, Gussenbauer, Kappeler.) In advanced cases the benefit obtained is of short duration. Of 25 cases only 1 case remained healthy after one year. (H. Braun.) Tracheotomy, which may be necessary as a palliative measure, gives only temporary relief, as above mentioned, even when performed below the seat of obstruction.

CRETINISM.

Cretinism is observed only where goitre is endemic. Fodéré considers goitre the first symptom of a process of degeneration, while cretinism is the last stage; and Virchow emphasized years ago the intimate connection between goitre and cretinism. v. Wagner reports an observation which demonstrates that cretinism, just as goitre, is secondary to changes produced by water. Goitre and cretinism are

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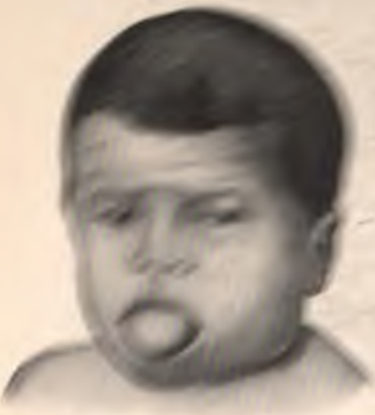
[illegible]

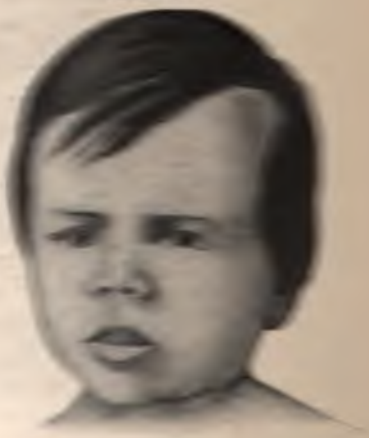
[illegible]

FIG. [illegible]



[illegible] in a child aged four years, before the administration of thyroid gland. (v. Bruns.)

FIG. [illegible]

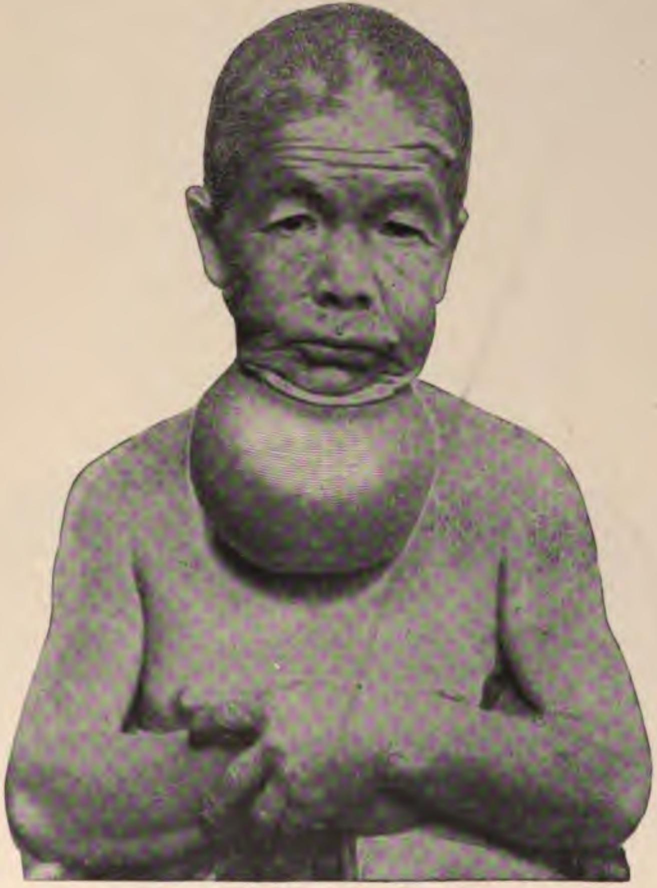


Same patient after the administration of thyroid gland.

Treatment.—Up to within a short time the treatment of this disease has been almost hopeless. The symptoms have been relieved by treatment with thyroid only during the last few years. It is evident on looking at the illustration of a patient treated in v. Bruns' clinic how much improvement is to be obtained by this form of treatment. (Figs. 191 and 192.) Of course, no cure is to be expected in cases in which

Idiocy of Cretins.—The idiocy of cretins is considered to be a disturbance of cerebral development (v. Wagner), and is analogous to the disturbed growth and sexual condition. Disturbances of the sensory organs should be distinguished from those of mental capacity. Both are present. Of the special organs of sense, hearing is most interfered with. No constant cause has as yet been found for this condition (pharyngeal tonsil, Habermann). A child that is perfectly healthy but has poor hearing learns to speak with difficulty. This relation is more marked in cretins. The disturbances of speech are therefore considered to be secondary to those of hearing. Many cretins would not be so stupid if they had learned to talk. (v. Wagner.) In severe cases speech is so much interfered with that the cretins are only able to make inarticulate noises. Cretins may be employed for light housework or mechanical work. Generally they are stupid and apathetic

FIG. 120.



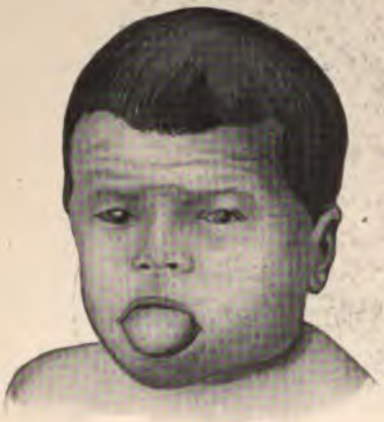
Goitre and cretinism. (v. Bruns.)

and rarely aroused. Idiocy is chiefly due to insufficient development of the senses, so that a cretin remains at the level of a newborn child. The gait drags and there is a tendency to fall forward. In other cases it is duck-like, as with patients with a double dislocation of the hip.

The Thyroid Gland of Cretins.—The thyroid gland is always changed in cretins. Usually there is some form of goitre. (Fig. 120.) Of 3600 cretins, 1125 had goitre. In the severest types the gland may be absent. Breathing, eating, defecating, and urinating are the only objects in life of these unfortunate individuals. These cretins have no inclination to move about, hence the name "human plant." The term "Thiermensch" has been applied to the milder types, in which the individual is about on a level with a well house-broken dog.

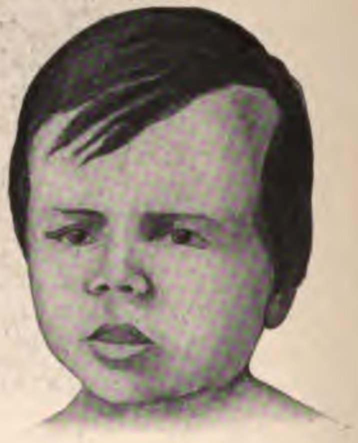
Aside from these pronounced types of cretinism, there are in regions where the disease is endemic forms in which the symptoms of cretinism are slight and the intelligence of the individual is well developed. In other cases the only symptom is deafness. v. Wagner states that in provinces where the greatest number of cretins are to be found (Kärnten, Salzburg, Steiermark), there is also the greatest number of deaf and dumb individuals. Kocher found goitre present in all deaf and dumb people examined by him. According to his view, this is due to insufficient function of the maternal thyroid gland, and is a remnant of congenital cachexia thyreopriva.

FIG. 121.



Myxœdema in a child aged four years, before the administration of thyroid gland. (v. Bruns.)

FIG. 122.



Same patient after the administration of thyroid gland.

Treatment.—Up to within a short time the treatment of this disease has been almost hopeless. The symptoms have been relieved by treatment with thyroid only during the last few years. It is evident on looking at the illustration of a patient treated in v. Bruns' clinic how much improvement is to be obtained by this form of treatment. (Figs. 121 and 122.) Of course, no cure is to be expected in cases in which severe cretinism has persisted for years. v. Wagner suggested that in regions where goitre was endemic the people should always take small doses of iodine, for instance with salt, because he observed considerable improvement of the idiocy and rapid increase in development after prolonged use of this drug. The most effective prophylactic treatment in countries where cretinism is prevalent consists in improving the water-supply.

Sporadic cretinism (*infantile myxœdema*) is a disease almost identical with that just described, and should be considered a type of cretinism occurring in countries where goitre is not endemic. This disease is rare compared with the frequent occurrence of endemic cretinism and goitre. As in true cretins, there are present disturbances of growth, spongy condition of the skin, and lack of development of the genitals, as well as more or less pronounced idiocy. In the majority of cases there is not only no goitre, but no gland at all. Chiari reported total absence of the gland in a case of this sort; only the epithelial bodies being present. The treatment with thyroid emphasizes the fact that this condition is due to absence of the thyroid gland. Marked improvement of the symptoms follows transplantation of gland-tissue or administration of thyroid gland.

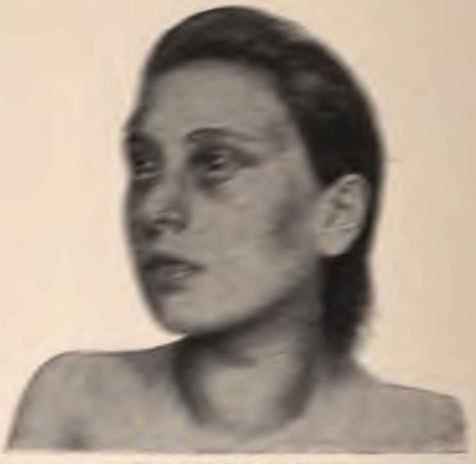
MYXŒDEMA.

Symptoms.—Whenever the thyroid gland gradually disappears in adults characteristic symptoms develop to which the term myxœdema has been applied. (Mosler, Wernher, Charcot, Gull, Ord.) Two symptoms are especially prominent: changes in the skin and in the psychic condition of the patient. There is no disturbance of growth because the disease develops in adults. The condition of the thyroid gland is of especial interest.

The skin may be tense and swollen, especially that of the eyelids, which may resemble thick sacs, so that the eyes can be only partially opened. The power of mimicry is lost, the tongue is thick and but slightly movable, the hands resemble the feet of moles, and pad-like swellings develop especially in the supraclavicular fossa. The skin is pale and cold, without secretion, just like that of a cretin. Microscopically there are an overgrowth of fibrillæ and an increase of nuclei. Chemical examination shows increased quantities of mucin. The conductibility of the skin is increased and in cold weather the thickening is much more pronounced. The hair becomes brittle, breaks off, and falls out, as do the teeth and nails. The pulse is slow, and the percentage of hæmoglobin in the blood is diminished, just as after excision of the thyroid gland.

The psychic disturbances manifest themselves as an apathy that may increase to stupidity. The patients resemble hibernating animals. (Charcot.) Defective memory and inability to judge competently may develop in individuals who previously have been perfectly healthy or ther [illegible]. [illegible] arteries occur in both conditions. The goitre is uniformly firm, and is generally speaking, not large, so that pressure-symptoms appear in only a small number of cases. Palpitation of the heart is one of the earliest and most annoying symptoms; the beats may number 140 a minute. With complicating myocarditis there may be associated severe attacks of angina pectoris. Exophthalmos is accompanied by numerous other ocular symptoms, chief of which is Graefe's sign: the upper lid follows changes in the visual plane, moving in the vertical line more slowly than normal. Stellwag's sign consists in an abnormal separation of the lids; and Möbius' symptom is insufficient accommodation without diplopia. The tremor, which is quite frequent, resembles the trembling of alcoholics, but differs from this in that it involves not only the muscles of the extremities, but also those of the trunk. There are changes in the skin which are considered to be vasomotor in origin, and there are disturbances of secretion, such as increased perspiration, abnormal pigmentation, œdema, circumscribed hyperæmia. The power of conduction of the electrical current is diminished on account of the dry condition of the skin, so that the galvanometer shows considerably increased excursions compared with a healthy individual. (Vigouroux.) Sometimes there are muscular weakness, emaciation, diarrhœa, and numerous nervous symptoms that resemble neurasthenia. Tabes and hysteria should be mentioned as complications, and myxœdema has been known to develop.

FIG. 132.



Struma in Graves' disease.

Diagnosis.—The diagnosis is usually easy. In the early stages of the disease and in cases that are not well marked it may be difficult. At the present time all of these cases belong to the field of internal medicine.

Prognosis.—The course of the disease is insidious, although cases a calf or a sheep, or one to three tablets of the dried gland. The same favorable results are observed after using Baumann's iodothyrin, so that proof is furnished that this is one of the most active constituents at least of the thyroid gland.

Symptoms due to Removal or Complete Destruction of the Thyroid Gland.—The improvement which follows treatment with thyroid indicates that the various symptoms which at first sight seem to be of different origin are in all probability due to removal of the thyroid gland. The symptoms are given in the following table:

1. Fœtal myxœdema (fœtal rhachitis).
2. Infantile myxœdema, usually endemic (cretinism), rarely sporadic.
3. Spontaneous myxœdema of adults (cachexie pachydermique).
4. Operative myxœdema: (*a*) due to total or almost complete excision; (*b*) secondary to destruction of the gland owing to suppuration.

Myxœdema may be of acute or chronic onset (tetania thyreopriva or cachexia thyreopriva).

Graves' disease, which will be considered later, is probably not due to absence of the thyroid gland, as in the above-described conditions, but is a disease secondary to some abnormal (increased?) function of the thyroid.

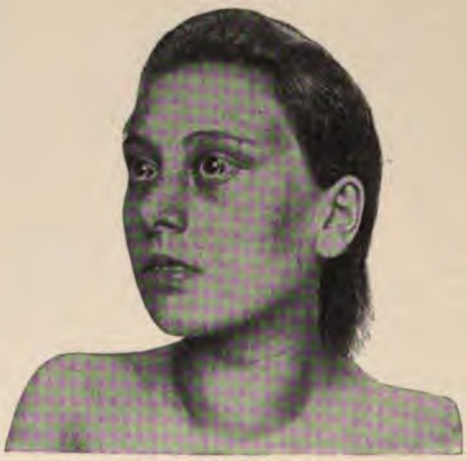
GRAVES' DISEASE (MORBUS BASEDOWII).

This condition, which is intimately connected with disease of the thyroid gland, has been repeatedly removed from the domain of internal treatment and made the object of surgical interference, a method of treatment that has been especially favored by the theory of Möbius, which claims that hyperthyroidization, due to excessive secretion of thyroid fluid, forms, as it were, the counterpart of myxœdema. According to this view, any sort of interference is justifiable that promises to diminish the amount of secretion by diminishing the size of the gland. Tillaux and Rehn were first to attack successfully the goitre of Graves' disease. The subsequent development of this form of treatment is due to the efforts of v. Mikulicz, Kocher, Krönlein, Trendelenburg, Wolff, and others.

Etiology.—Nothing definite is known of the etiology of the disease. Some psychic injury or neuropathic damage is said to be of importance. It is certain that women are much more frequently affected by Basedow's disease. Buschan considers the proportion to be about 46 to 1.

Symptoms.—The chief symptoms of this disease are goitre, exophthalmos, tachycardia, and tremor. In pronounced cases there are other symptoms present which are of nervous origin. It is important to remember that any individual symptom may be absent, and that the so-called Graves' symptoms may be present in the course of any goitre, from simple cysts to malignant growths of the thyroid. (Fig. 125.) Genuine and secondary Graves' disease are distinguished one from the other in this way. Undeveloped varieties occur in both conditions. The goitre is moderately firm, and is, generally speaking, not large, so that pressure-symptoms appear as a rule in only a small number of cases. Palpitation of the heart is one of the earliest and most annoying symptoms; the beats may number 140 a minute. With complicating myocarditis there may be associated severe attacks of angina pectoris. Exophthalmos is accompanied by numerous other ocular symptoms, chief of which is Gräfe's sign: the upper lid follows changes in the visual plane, varying in the vertical line more slowly than normal. Stellwag's sign consists in an abnormal separation at the lids; and Möbius' symptom is insufficient accommodation without diplopia. The tremor, which is quite frequent, resembles the trembling of alcoholics, but differs from this in that it involves not only the muscles of the extremities, but also those of the trunk. There are changes in the skin which are considered to be vasomotor in origin, and there are disturbances of secretion, such as increased perspiration, abnormal pigmentation, œdema, circumscribed hyperæmia. The power of conduction of the electrical current is diminished on account of the dry condition of the skin, so that the galvanometer shows considerably increased excursions compared with a healthy individual. (Vigouroux.) Sometimes there are muscular weakness, emaciation, diarrhœa, and numerous nervous symptoms that resemble neurasthenia. Tabes and hysteria should be mentioned as complications, and myxœdema has been known to develop.

FIG. 124.



Struma in Graves' disease.

Diagnosis.—The diagnosis is usually easy. In the early stages of the disease and in cases that are not well marked it may be difficult. At the present time all of these cases belong to the field of internal medicine.

Prognosis.—The course of the disease is insidious, although cases occur which have a sudden onset and run a precipitate course. The latter cases lead one to consider poisoning by thyroid secretions. Ordinarily, frequent spontaneous remission of symptoms is observed in the course of the disease, and at times the condition is said to disappear apparently spontaneously. The fate of a patient is ordinarily determined by the cardiac conditions. Acute cases die of exhausting diarrhœa. In chronic fatal cases (about 13 per cent.) death is either due to some disease of the heart or some intercurrent affection. Histological investigation has been unable to demonstrate any constant peripheral or central change in the nervous system. All conditions previously reported, especially atrophy of the sympathetic nerve and changes in the cord, have been shown to be of doubtful significance. Goitre is very characteristic, because of the complete absence of colloid, which is replaced by a thin secretion coagulating in shreds. It is of practical importance that the thyroid gland may show marked changes microscopically, although symptoms were absent during life.

Treatment.—It would be of the greatest importance as regards treatment if authors could come to some understanding as to the nature of the disease. Two views are maintained: one view considers the disease to be an affection of the nervous system, especially of the sympathetic system or of the medulla without anatomical change, a neurosis as it were. This view has developed from the old theory of Köben, which placed the seat of disease in the cervical sympathetic. The other view is a chemical theory, which claims that there is an overabundance or faulty secretion of thyroidea, which poisons the system, especially the central nervous system. (Möbius.) The correctness of one or the other of these views cannot be absolutely proved, but at the present time the second seems to be more acceptable, because it is the only way of explaining the results of surgical treatment, and because a number of symptoms and anatomical conditions can as yet only be accounted for in this way.

Internal treatment must be first considered, because the disease not infrequently disappears spontaneously. Internal treatment consists in observing hygienic methods of living, and avoidance of physical and mental strain. Hydrotherapy and living in a high latitude are to be recommended. Iron, belladonna, and arsenic are of symptomatic value, especially in cases complicated with chlorosis. Kocher observed favorable results from the use of sodium phosphate, which seemed to diminish the nervous symptoms of the patient just as the bromides do. The advocates of the neurosis theory recommend the use of the galvanic current in various forms. Others claim that the faradic current is a valuable therapeutic measure. The fact that the symptoms are electrolized as it were—for instance, the sympathetic nerve or the exophthalmos is treated with galvanism—is pretty good evidence that the effect is due to suggestion. Treatment with tissue extract, iodothyrin, and thyroidin, is of greater importance. Most authors have observed that the symptoms became rapidly worse after using these drugs, in accordance with the theory of hypersecretion. Nevertheless, cases have been reported in which improvement has followed. In all probability, so-called secondary Graves' disease was present in those cases in which thyroid produced retrograde changes in a primary goitre. v. Mikulicz observed improvement in the symptoms after treating a series of cases with thymus. No opinion can be expressed as yet regarding the antagonism of thymus and thyroidea based upon these experiments. The therapeutic value of the interesting theoretic experiments of Bellet and Enriquez with the serum of animals whose thyroid had been excised, which is supposed to counteract all symptoms due to hypersecretion of the thyroid gland, is uncertain as yet.

The dangers of surgical interference in Graves' disease are greater than in uncomplicated goitre operations, and one decides upon surgical treatment only after internal treatment has been devoid of results. In following this principle, which is doubtless correct, there is the danger of overlooking the period when interference is of value. The technical difficulties do not render the operation difficult, but the resistance of the patient is so slight that any interference in the region of the thyroid gland or on the sympathetic nerve is dangerous to the life of the patient. The individual peculiarities of patients with Graves' disease, which is called lowered resistance in general, increases with the duration of the disease, as does the danger from operation. Whenever there is a notable increase in symptoms and cachexia one should decide to interfere surgically. For this reason it is well, as recommended by Rehn and Nonne, to operate immediately in acute cases that seem like a sudden intoxication of the body by thyroid, even when no increase in the gland can be demonstrated. The local effect of the goitre, provided this gives rise to symptoms in secondary Graves' disease, may form the indication for interference. (Riedel.) In exceptional cases the social position of the patient will justify operation, especially when his position in life does not permit of long-continued and tedious treatment. A number of methods have been recommended, only five of which may be here considered: ligation of the arteries, enucleation, exothyropexy, partial strumectomy, and resection of the sympathetic.

Exothyropexy has fewest advocates, and has not without justification been termed incomplete strumectomy. The lack of danger claimed by its originator, Jaboulay, has not been corroborated, and the method has been almost completely abandoned. The cosmetic result of this operation is very bad.

Of the remaining methods, that one is to be chosen which at the time seems to be least severe without sacrificing the chances of success. Partial strumectomy is to be considered the normal methed of procedure. The technic differs in no way in Graves' disease from that of operations upon uncomplicated types of goitre.

The accidents which may occur during operation, the most frequent of which is collapse, have been claimed to be due to the lymphatic chlorotic constitution, or to sudden flooding of the body with thyroid poison, diminished resistance of the body with simultaneous increase of irritability—status thymicus. (Paultauf.) Collapse from chloroform or operative shock, which is most to be feared on account of the vicinity of the large nerves of the neck, and hemorrhage may be the cause of death. The author has recently seen a case in which collapse took place after the operation, resembling that from chloroform in Graves' disease, although Schleich anæsthesia had been used. The patient, who had marked Graves' disease, died a few moments after the operation. Autopsy showed an enlarged thymus. The dangers of any operation are increased by the preliminary use of thyroid extract. This should never be administered when there is any probability that surgical interference will become necessary. (Angerer.) Two hundred and thirty reported cases show that 45 per cent. recovered after surgical interference in Graves' disease. In 23 per cent. there was marked improvement, in 11 per cent. slight improvement, and in 10 per cent. there was no improvement whatever; 7.5 per cent. succumbed, and in the remainder the result was unknown. These cases were not subdivided into genuine and secondary Graves' disease. In genuine cases the number of recoveries is about 36 per cent., while the percentage of improved cases and the percentage of deaths is somewhat larger than in the general statistics. Those cases are included among the cures in which a slight degree of exophthalmos remained, although the subjective nervous symptoms disappeared almost completely and the tachycardia and tremor were absent. The subjective signs and exophthalmos disappear very slowly if they have persisted for any length of time. Fifty cases of cures lasting from two to ten years have been reported in literature. It must, however, be mentioned that in rare cases recurrences have been observed, usually associated with increase in the size of the remaining portion of the thyroid gland. (Riedel.)

The sympathetic has been attacked, especially by Jaboulay and Jonnesco, based upon the theoretic reasoning of Abadie. Abadie assumes that the vasomotor fibres of the bulbar sympathetic centre are irritated. Exophthalmos, struma, and tachycardia are supposed to be due to dilatation of the vessels, whereas the excess of secretion of the thyroid gland is explained by hyperæmia of the organ. This theory does not seem to correspond to anatomical and clinical observations, and even contradicts the results of operation upon the sympathetic nerve. Jaboulay divides the cervical sympathetic between the first and second ganglion and turns out the ends. Jonnesco has of late resected the sympathetic, because simple division has been productive of only temporary improvement of exophthalmos. He resects as a rule the third cervical ganglion. According to the statement of other authors who have had opportunities to test this method, the operation is extremely difficult. The results of this operation seem to be far less favorable than the results of operations upon the thyroid gland, although too few cases have been reported to allow of an absolute statement. The only symptom that seems to be favorably influenced constantly is the exophthalmos. Tremor and tachycardia persist in [illegible] the thymus [illegible] marked symptoms [illegible] The symptoms [illegible] the obstruction is [illegible] established, the only [illegible] in the anterior [illegible] The thymus is [illegible] gland is removed [illegible] although the [illegible] King's [illegible] greater portion of the [illegible]

TUMORS OF THE THYMUS

[illegible] Sarcomata [illegible] anterior medi- [illegible] been made during [illegible] lymphatic glandular [illegible] the course of malignant [illegible] primary growths. Fischer [illegible] in whom tracheotomy failed [illegible] and he died of asphyxia. The tentative diag- [illegible] malignant lymphoma. The autopsy showed typical pseudo-

CHAPTER IX.

DISEASES OF THE THYMUS.

THE physiological significance and pathology of the thymus are unknown, and the gland rarely becomes of clinical interest. Embryological investigations and animal experiments, although valuable in determining the function of other glands without ducts, have been negative in the case of the thymus. The number of cases in which it has entered into clinical diagnosis and has been the object of pathological investigation are few. It is not possible to consider the pathology of diseases of the thymus gland from a surgical standpoint because so little is known of the functions of the organ. It was formerly believed that the thymus persisted only during fœtal life and the first years after birth, and that it gradually disappeared and was replaced by fatty tissue. The fact that pathological conditions of the organ were observed only in the earliest years of life seems to be in harmony with this view. Waldeyer and Sappey demonstrated that there is always present in the anterior mediastinum an organ about the size of the thymus in the newborn infant, called the retrosternal or thymic fatty body, which contains more or less gland parenchyma. This explains how a thymus gland of normal structure is found in some adults. It presents as a firm mass between the innominate artery and the left common carotid, aud reaches from the pericardium nearly up to the thyroid.

HYPERPLASIA OF THE THYMUS.

This condition is of the greatest clinical interest because it seems to be connected etiologically with thymus death and asthmathymicum. The diagnosis has in nearly all cases reported been made after death. The patients were usually children that died seemingly of sudden suffocation, although apparently in perfect health. Usually no accurate clinical examination has been made. In rare cases the course of the disease was not so precipitate and chronic dyspnœa had been produced by enlargement of the gland. The disease in these cases has been repeatedly recognized, and 3 cases have been successfully operated upon. Just what the relation of hyperplasia is to these sudden fatal cases has not been explained. It seems probable that compression of the trachea is responsible, because the thymus becomes jammed in the upper margin of the thorax on bending the head back and then closes the trachea by pressing upon it. Weigert and Beneke have demonstrated evidence of pressure. In other cases pressure on the pulmonary arteries is supposed to have led to œdema of the lungs, or pressure upon the nerves may have produced reflex spasm of the glottis. These views assume that hyperplasia is the direct cause of death, but Paltauf has shown that usually there can be no purely mechanical pressure-effect, and that enlargement of the thymus is only part of a clinical picture in which there is general lymphatic hyperplasia. Usually there are carotid changes associated with this condition (small aorta). Paltauf claims that the cause of death is some abnormal lymphochlorotic condition that may be followed by sudden cessation of the heart action, due to damage of the intracardial centres. This peculiarity, which in children is frequently associated with rickets or scrofula, and in adults with Graves' disease or acromegaly, may be recognized by the sedentary habits of the patients, swelling of the lymph-glands or of the lymphoid tissue in the pharynx, and sometimes by increased dulness in the region of the thymus. In rare cases the gland may become intermittently visible at the sternal notch with forced respiration. v. Kundrat ascribes a number of fatal cases under anæsthesia to this so-called status lymphaticus, which otherwise would have been attributed to idiosyncrasy to general anæsthetics. On the other hand, it is indisputable that the enlarged thymus may press to a certain extent upon the trachea and the intrathoracic nerve-trunk. This condition is found during the early years of life in cases of chronic dyspnœa with distinct enlargement of the thymus, while the lungs show no evidence of disease, and where marked symptoms of stenosis of the trachea or a large bronchi exist. The symptoms are not especially influenced by tracheotomy because the obstruction is within the chest. When the diagnosis has been established, the only method of treatment consists in removing the cause in the anterior mediastinum, as recommended by Rehn and König. The thymus is exposed and dislocated (ectropexy) or the excess of gland is removed between ligatures. (König.) Two children treated in this way recovered: Rehn's case, two and one-half years of age, recovered, although the operation was complicated by preliminary tracheotomy; König's case nine weeks old, recovered from resection of the greater portion of the gland without the development of symptoms subsequently. Purrucker removed the thymus successfully in a third case.

TUMORS OF THE THYMUS.

By reason of their seat and the difficulties of diagnosis tumors of the thymus are rarely the subject of surgical interference. Sarcomata are most common, and appear as nodular tumors in the anterior mediastinum. In all probability a diagnosis has never been made during life, because any swelling is supposed to be a lymphatic glandular tumor. Tumors of the thymus developing in the course of malignant lymphoma are in some way related to these primary growths. Fischer reports the case of a boy five years of age in whom tracheotomy failed to relieve dyspnœa, and who died of asphyxia. The tentative diagnosis was malignant lymphoma. The autopsy showed typical pseudoleukæmia and a tumor of the thymus causing stenosis of the trachea. French authors report carcinomata of the thymus in adults that produced symptoms of retrosternal tumors and became visible at the sternal notch.

A congenital change of the thymus known as Dubois' abscess is of interest. In children with congenital syphilis Dubois found cavities, containing a creamy, purulent fluid. Investigation showed that in a number of cases these were broken-down gummata, but that in the majority of the cases the cavities were not abscesses, and that they developed as cysts by concentric overgrowth of epithelial elements. No connection between these tumors and congenital syphilis could be made out.

INJURIES, MALFORMATIONS, AND DISEASES OF THE THORAX AND ITS CONTENTS.

By Prof. Dr. F. v. Riedinger and Dr. H. Kümmell.

CHAPTER X.

INJURIES OF THE THORAX.

CONTUSIONS OF THE CHEST.

Etiology.—By contusion is meant an injury produced by a blunt force. The amount of compression is so great as to produce marked changes in the internal organs without affecting the wall of the chest to any great extent. Ignorance of this frequently has been the cause of underrating the importance of such injury. According to Pirogoff, the severity of these lesions is equal to that of perforating wounds. The injury is usually sudden and unexpected, and differs from injuries which are inflicted more slowly. The latter are much less severe because the lungs adapt themselves to the limitation of space. It is well known that the ensiform cartilage of the sternum may be pressed backward almost to the vertebral column without producing injury. The causes of contusion of the chest are usually violent pressure, such as falling from a height, or being jammed between bodies, etc.

The injuries of the intrathoracic organs may be numerous, and affect the lungs, the heart, the large vessels, the trachea, or the diaphragm. Sometimes the liver, spleen, kidneys, and intestines are secondarily affected. The lung and pleura are most frequently involved. Gosselin has demonstrated that the lung and pleura are injured to a greater extent when the force is suddenly and unexpectedly applied, so that the air does not have sufficient time to escape. This takes place especially when there is sudden closure of the glottis. If the chest of a corpse is suddenly compressed, the lungs simply collapse; but if one of the bronchi be previously closed, the lung-tissue will be torn. Injuries of the heart may be due to simple compression, although the effect of concussion will be of importance here, just as in the case of the large vessels, of the œsophagus, and of other organs. Any pathological change that may be present, which is not uncommonly the case in the heart, will have certain influence.

Diagnosis.—The clinical signs may be complex, corresponding to the degree of destruction. Slight injuries as a rule produce no clinical signs. Laceration of lung-tissue, however, may give rise to grave symptoms. Aside from concussion of the chest, which is usually associated with contusions, hemorrhage into the pleura, especially when bilateral, produces threatening symptoms. Bloody froth at the mouth and marked cyanosis and dyspnœa are usually present. In many cases symptoms of anæmia, such as pallor, lowered surface temperature, and tremor, are most marked, and indicate damage to some important organ and internal hemorrhage.

Pneumothorax may develop as the result of injury to a large bronchus, and may be associated with hæmothorax. Rupture of the trachea and large vessels of the neck or heart results fatally as a rule within a short time. Simultaneous injury to abdominal organs may complicate the clinical picture to such a degree that an accurate diagnosis is almost impossible. Sometimes the symptoms referable to injuries of the thoracic organs seem insignificant compared with those due to involvement of the abdominal viscera.

Whenever there is rupture of the diaphragm the contents of the abdomen may be displaced into the thoracic cavity. Strange to say, this condition may frequently be productive of scarcely any symptoms. For this reason injuries of this sort are frequently overlooked. The author had a patient under his care in whom the stomach, a portion of the colon, and the liver were dislocated. The diagnosis was made at autopsy many years after the injury. It is important to recognize these anomalies because the organs may be injured in any attempt at exploratory puncture.

Emphysema of the subcutaneous tissue has been observed after contusions of the chest without demonstrable fracture of the ribs or perforation of the pleura. It must, however, be taken into consideration that these fractures may have been overlooked, because otherwise it would be difficult to explain this condition. Ewald and Kobert have demonstrated air in all portions of the bodies of animals subjected to continued artificial respiration, although the degree of pressure used was not great. They assume, contrary to the general view, that the pleura is not an air-tight compartment. Emphysema of the mediastinum is most dangerous because it may result in severe disturbances of respiration and circulation.

Hernia of the lungs has been observed without fracture of the ribs. This condition may be simply secondary to violent attacks of coughing. Hertzberg reports several such cases, and Wightmann has also reported a case in a trumpeter who developed a tumor in the back to the left of the seventh and eighth spinous processes. On incision this was found to be a piece of lung-tissue.

If the patient survives the first shock, a series of secondary symptoms may develop that are often severe. Aside from pneumothorax, which usually disappears quickly, although it may remain for some time and exert pressure, the effusion of blood into the pleura may result in secondary complications. There is almost always pain, aside from the interference with breathing. An exudate develops only in individual cases, and empyema with high fever is infrequent. The outcome of the condition cannot be foretold because recovery has taken place with extensive injury to the lungs and severe initial symptoms. König emphasizes the benign character of these subcutaneous injuries in comparison with compound lesions. Hæmoptysis, which is usually present in injuries of the lung-tissue, may be absent, and manifest itself later as a rusty sputum.

Litten called attention to the so-called contusion pneumonia, which has also been reported by Billroth and Wahl. The clinical signs are similar to those of genuine pneumonia, although the course is much milder. There are severe cases, and one of the author's patients succumbed to a bilateral pneumonia of this sort. Demuth believes that contusion pneumonia is never croupous because the most important signs, such as initial chill, high temperature, prostration, perspiration, albumin in the urine, enlargement of the spleen, herpes, and sudden fall of temperature, are never present. Demuth considers that these cases of pneumonia are inflammatory infiltrations, lobar blood-infiltrations, and that the fever is due to absorption of the products of decomposition and of blood. The inflammatory condition present in the infiltrated regions, according to the author's view, is best explained by infection by bacteria. The fever is usually higher than in so-called ferment absorption, continues longer, and some patients succumb rapidly. Pneumococci have been found present in large numbers. H. Gross found diplococci. Some of the cases are certainly croupous pneumonia. It may be possible that infection is already present as emphasized by Demuth; although it can be assumed with equal reason that the changes in the lung produced by the contusion, especially the extravasation of blood, favor the development of croupous pneumonia just as slight trauma may favor acute osteomyelitis. Dumstrey claims that injuries to the lung or to the alveolar epithelium furnish the *locus minoris resistentiæ* for the diplococci. These bacteria require about four to twelve hours to develop, so that the term contusion pneumonia can only be applied when the initial chill takes place in the first few days after injury.

Tuberculosis has been observed to develop, or existing tuberculosis to increase secondarily.

Perth's observations explain the lobar blood infiltration. This author has observed extensive extravasation of blood in the neck and head secondary to compression of the thorax without these regions being directly affected. Marked hemorrhages in the orbit and conjunctiva on both sides have been observed. The face became cyanotic and the power of vision was temporarily lost. These symptoms disappeared rapidly, although the sclera remained discolored for five or six weeks. Perth claims that these conditions are due to transmission of pressure to the veins of the head and neck, because there are no valves in this region. Braun, Vogt, and Hüter have made similar observations after compression of the abdomen. It is probable that the abdomen was affected in the case described by Perthes.

Sugar and albumin are frequently found in the urine after severe contusions. Parascandalo has called attention to the fact that the blood-serum of animals that had been subjected to severe injuries of the chest and abdomen has marked toxic properties. If large doses of this serum were injected into animals of the same species, they died immediately; when smaller doses were used, they succumbed after some time. The blood appeared to have a diminished power of oxidation and diminished alkalinity, with increased power of coagulation. The urotoxic coefficient of the urine was increased.

Reineboth's investigations seem to indicate that the sudden distention of the vessels of the pulmonary circulation limits the amount of blood entering the left ventricle with secondary lowering of the blood-pressure. This hypothesis corresponds to Lichtheim's investigations, who was able to close the greater part of the pulmonary circulation without producing diminution of pressure in the carotids or in the veins, which would only be possible with marked dilatation of the pulmonary capillary system. Grönstad observed occlusion of both femoral vessels and gangrene after contusions of the chest in a girl fourteen years of age.

Prognosis.—The prognosis of contusions of the chest with injuries of viscera is always serious. Many of the patients die immediately; others succumb later; and only a small percentage recover completely. There is usually a certain amount of damage to various organs.

Treatment.—The treatment of contusions of the chest depends upon the symptoms which predominate. Absolute rest in bed and a horizontal position are imperative. Ice may be applied to the chest-wall. Whenever there is marked dyspnœa subcutaneous injections of morphine may give relief. Infusions of salt solution may be necessary with marked anæmia. It does not seem probable that administration of ergot can be beneficial. Whenever there are marked signs of pressure, especially with displacement of the heart, the blood should be aspirated, although care should be taken not to do this too early. This treatment has been followed by good results in some patients, whereas in others it did not avert the fatal result. It should not be overlooked that the results are sometimes favorable even without operative interference, in spite of marked and prolonged difficulty with respiration. In these cases the breathing may be so rapid and superficial that it does not seem possible that a favorable termination can ensue.

When the hemorrhage is from some unknown source a surgeon will hesitate to operate for the purpose of checking the bleeding. Schuh recommends puncture of the chest-wall in cases of tense pneumothorax. Curling and König also advocate this procedure. Secondary conditions, such as pleural exudates or abscesses of the lung, should be removed as early as possible by aspiration or incision. Hæmatoma of the chest-wall, due to contusing force, are uncommon, because of the anatomical conditions. As a rule these injuries are insignificant, although extensive extravasation of blood has been observed. (Zwicke.) As a rule the effused blood disappears quickly and demands no special attention. Compression and massage favor absorption.

CONCUSSION OF THE CHEST.

Etiology.—In counterdistinction to contusions of the chest, concussion is the result of some blunt force acting on the chest-wall without producing much if any change in the thorax itself, nor in the contained viscera. In the majority of cases the individual has no general symptoms whatever, while in other cases characteristic clinical symptoms develop. Some patients collapse with deep inspiration after an injury and become pale and have lowering of surface temperature. The sternum is usually the seat of injury. The pulse is scarcely appreciable, very slow, and intermittent. Respiration is superficial, hurried, and irregular. Many of the patients recover immediately, others slowly, and a few never regain consciousness, but succumb immediately to the injury. A slight and a severe type may be therefore distinguished.

Clinical observations are few. Nélaton was first to publish a case bearing on this subject. A porter fell upon the anterior surface of the chest and died immediately; the autopsy showed slight contusions of the chest-wall, but no marked injury of the internal organs. Reubold autopsied an old man who died immediately after a short, sharp blow upon the anterior portion of the chest, and could find nothing to explain the fatal result. The slight extravasations in the pia do not seem sufficient explanation. All cases have not been examined as carefully as the above, and caution should be exercised in forming an opinion. In some cases it has been thought that there was concussion of the chest, whereas autopsy showed severe injuries to the internal organs. One of the author's patients received a sharp blow upon the sternum from the pole of a team. He collapsed immediately and was put to bed. After some time he became conscious, and in two days resumed work. Careful and repeated examination of the chest was always negative. The contused area was slightly painful, and he expectorated a slight amount of blood-tinged sputum once or twice. These cases are probably all contusions of the chest, and in all probability the cases which die immediately after injury and in which the autopsy shows fracture of the sternum but no other injury, belong to this group. Fracture of the sternum alone is not sufficient to produce death. Meola came to the conclusion, as the result of experiments, that concussion of the chest was due to irritation of the vagus and paralysis of the sympathetic.

The author's experiments with rabbits showed that blows upon the chest were followed by lowering of the blood-pressure in the carotids, just as is seen on applying the intermittent current to the peripheral portion of the vagus. Direct pressure upon the heart can probably be excluded in the experiments. The resulting disturbance in the circulation of the brain caused the respiration to become slower and deeper. After division of the cervical sympathetic the respiration became rapid and shorter. Considering the scarcity of clinical observations and autopsy reports, it is not to be wondered that many surgeons regard the fatal results in these cases due to lesions of the viscera of the thorax and abdomen or due to shock.

Symptoms.—Concussion of the chest presents various symptoms, chief of which is lowering of the blood-pressure, which in all probability is due to direct irritation of the intrathoracic vagus. The heart, which is near the anterior wall of the chest, may be shaken and the fibres of the vagus directly irritated, which would explain the lowering of pressure after division of the nerve. The heart may stop in diastole following a sharp blow. Prolonged lowering of the blood-pressure is supposed to be due chiefly to the action of the cardiac depressors and other depressor nerves in the affected area, as well as the sympathetic. Cerebral anæmia may be secondary to overfilling of the abdominal vessels. Goltz's experiments demonstrated this reflex action after blows upon the abdominal viscera. This type of anæmia may be a very dangerous symptom. Severe symptoms and the fatal cases following a blow upon the chest, especially upon the anterior surface, in the absence of marked injuries to the viscera, are explained by disturbances of the circulation and of the central nervous system, produced by cessation of the heart action secondary to intrathoracic irritation of the vagus, with subsequent prolonged diminution of the tonus in the peripheral vessels.

Diagnosis.—It is not always easy at first to make a differential diagnosis between concussion of the chest and contusion of the chest. The symptoms subsequently developing, especially hæmoptysis, will enable a more accurate diagnosis.

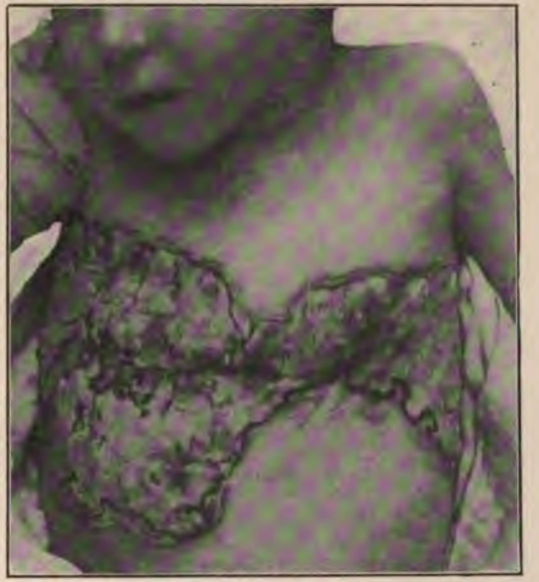
Prognosis.—The prognosis of concussion of the chest is generally favorable. The symptoms disappear as a rule quickly, although when there are injuries of the organs the signs may persist. In some cases concussion of the chest, without complications, may be followed by immediate death.

Treatment.—The chief point in the treatment is to put the patient at once into a horizontal position. Artificial respiration, provided the condition of the chest-wall permit, and subcutaneous injections of ether will be of service. Rest and a proper position, however, are more important. Autotransfusion—*i. e.*, elevation of the extremities—is to be recommended. Stimulants are more apt to do harm at first, but may be of value later.

NON-PERFORATING INJURIES OF THE CHEST.

Burns of the chest and back are comparatively rare, but when present they may be extensive. They are observed chiefly in children, who spill hot fluids over themselves. Extensive and deep burns of the back are seen often in the insane who lean against hot stoves. Slight cases heal as a rule without complication, while severe injuries may affect the pleura. Serous and purulent exudates have been reported. The author applies a thick zinc or boric acid ointment dressing, which materially aids in alleviating the pain. When the burns are more superficial than deep, antiseptics should be used. Morphine may be necessary on account of the intense pain. Sloughs should not be forcibly removed. Thiersch grafting should be done when there are extensive granulating surfaces. In many cases, however, this method is not successful, and it becomes necessary to make use of large flaps from the surroundings or transplant skin-flaps from the arm. Aspiration may be necessary on account of secondary accumulation of fluid in the chest. Collapse should be combated with autotransfusion, as recommended by Sonnenburg, or normal salt solution should be infused.

FIG. 125.

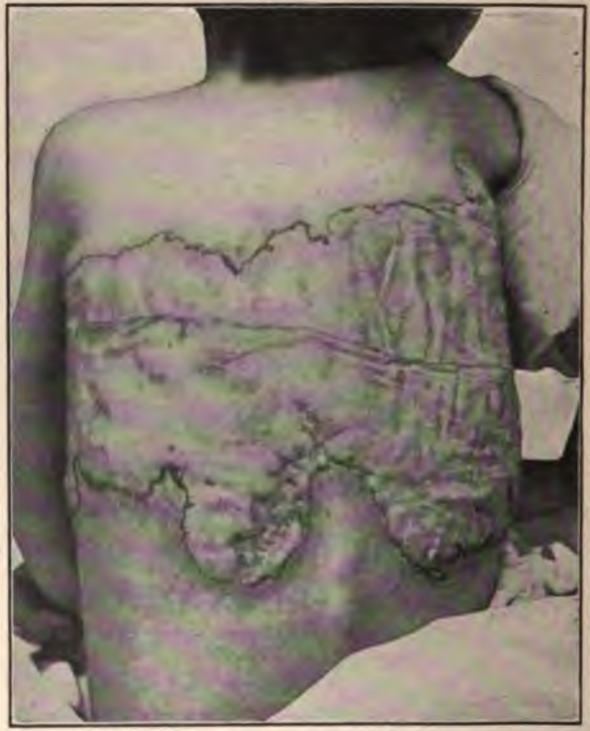


Extensive burn of trunk. Recovery. (Front.)

Stab- and *incised wounds* of the chest-wall are as a rule insignificant. Bleeding is usually slight, provided the internal mammary or intercostal artery has not been injured. Extensive suppuration and erysipelas may follow infection of the wound, and are feared on account of involvement of the pleura, which is not uncommon. In many cases it has been necessary to draw off the pleural effusion repeatedly.

Gunshot-wounds of the chest-wall vary according to the angle at which the projectile strikes the chest and the force of impact. A spent ball usually produces only a simple contusion of the skin, although one or more ribs may be fractured. These injuries were formerly considered to be due to air-pressure. Whenever the projectile strikes the chest in a more or less slanting direction, superficial grazed wounds are produced. If the ball perforates the skin, a blind sinus may be formed or the projectile may escape through the skin again at some distance from the point of entry. A track of this sort may be very long, especially if the direction is anteroposterior and the chest was struck along its upper and lateral portions. The chest may seem to have been perforated. An attempt to probe the canal soon meets with resistance, and if the arm is placed in the position it was held at the moment of injury, it may be possible to follow along the sinus. The author has observed several injuries of this sort, and Schjerning reports 3 cases in which it seemed as if the chest had been perforated. When the arm was raised, it was shown that the course, which seemed at first to be curved, was straight, and that the projectile did not circle the chest, but passed through the base of a pyramid of soft parts. It may seem at times as if there were two blind bullet-holes. These injuries have been called contour-wounds. The ball striking the chest at an angle, circles around the same for a considerable distance; and Dupuytren assumes that a projectile could encircle the chest several times and produce a series of openings. Up to the present time no autopsy, which was beyond question, has been reported. These views are probably due to errors in observation. A ball striking the chest-wall at an angle may change its direction after

FIG. 126.



Extensive burn of trunk. Recovery. (Rear.)

coming in contact with a rib. The sinus produced may be extensive. If the projectile has sufficient force, it will perforate the skin, or will come to rest immediately beneath it. The view that a ball may follow along in the loose connective tissue is not tenable; nor is it correct to claim that the ball may follow the course of a rib. Most sinuses traverse one or more ribs.

The course of injuries to the soft parts of the chest is usually favorable. Incised, lacerated, contused, and gunshot-wounds usually heal kindly provided there is no infection. In judging the nature of a wound, two points should be considered: first, whether the wound is infected; and second, whether it is a perforating wound. The latter question is more important, of course, although care must be taken on examining to avoid making a simple wound a perforating one.

Treatment.—The first indication in treatment consists in arresting hemorrhage. The chief source of hemorrhage is the long thoracic, the internal mammary, and the intercostal artery. After checking the hemorrhage, the wound itself must be attended to. As a rule it is not possible to decide whether the wound is infected or not. Hardly any wound will be absolutely free from germs. After accidental injuries it is usually possible immediately after the accident to obtain cultures containing colonies of pathogenic and non-pathogenic bacteria. Many of these wounds, however, heal in spite of this. The system is perfectly able of taking care of a certain quantity of these organisms, and the less blood remains in the wound, the greater the chances of rapid recovery.

The next question is, whether the surgeon shall treat the wound aseptically or antiseptically. It is true that antiseptic treatment cannot kill all of the bacteria, and that a sterile fluid is usually sufficient for the purpose of mechanically cleansing the wound. Many wounds, to be sure, heal without any treatment whatever. Personally the author prefers immediate cleansing of any wound that comes for treatment, even after some delay. It is his custom, in extensive wounds of the chest, to clean the surrounding skin with soap, ether, or alcohol, and with solutions of carbolic acid or corrosive sublimate after first antiseptically packing the wound. Any foreign bodies which may be present in the wound are removed as carefully as possible and the entire surface washed with a 2 per cent. solution of carbolic acid or a 1 : 1000 solution of corrosive sublimate.

Should it seem justifiable to close the wound with sutures, silk may be used, although these must not be placed sufficiently near together to prevent the escape of secretion from the wound. In all suspicious wounds the author uses a gauze drain and places very few sutures or none at all, provided the edges of the wound do not widely gap. In injuries to the chest-wall this is especially advisable, because one is not always sure that the pleura has not been injured, and that secretions of the wound may not enter and lead to pyothorax. A firm bandage of some sterile material is finally applied and the patient told to keep quiet. If recovery is uncomplicated, the first dressing should be left

[illegible]

[illegible] rax. The [illegible] the larger [illegible] pneumothorax. [illegible] retracts slowly [illegible] air and pneumothorax

[illegible] to the
[illegible] of the pleura
[illegible] wound of the left

by tying the vessel centrally. If this is not possible at the seat of division, it is well to ligate the vessel in the intercostal space immediately above and below. If necessary, the costal cartilage may be resected and the wound packed temporarily. An incision is made parallel to the rib, starting close to the margin of the sternum. After dividing the skin the pectoralis major and intercostal muscles are divided, which will expose the artery from the third space downward, accompanied by two veins. If it does not seem advisable to ligate the vessel, it is best to try packing the wound with iodoform gauze. The longer this is allowed to remain in place, the more likely one is to obtain definite closure of the vessel. The author has observed vicious secondary hemorrhage take place after ten days' packing, and has been obliged subsequently to ligate the artery.

Hemorrhage from the intercostal arteries is far less important than that from the internal mammary, although at times it may be dangerous, especially when the posterior vessels are affected. In the American Civil War 11 of 15 cases died. It should not be overlooked that other structures were not injured in the vast majority of these cases, and that many other complications were present, although fatal cases have been reported in which it would seem as if the vessel alone had been divided. The danger consists in the fact that aspiration, as emphasized by Froriep, does not permit the development of a thrombus in the vessel. In a case observed in v. Bruns' clinic the intercostal artery had been injured in the left eighth space, but had been packed as it were by the omentum. After resection a fatal hemorrhage took place.

The fact that cases are reported in which patients bled to death after resection of ribs should make every surgeon cautious. This has been observed even after simple puncture. (Dulac and Demarquay.) Secondary hemorrhages are not uncommon after gunshot-wounds affecting the intercostal artery, and are usually due to suppurative processes, just as in the case of the internal mammary. A case was reported in the American Civil War in which this accident occurred thirty-nine days after injury. Ligation of the artery was successful. It is probable that at first there was only a slight grazing of the vessel, and that when the slough separated later the hemorrhage took place. Most injuries to the intercostal vessels follow stab-wounds or gunshot-wounds, the former being more dangerous. As a rule, the pleura is injured at the same time, which complication is the chief source of danger. It is notable that hemorrhage from the intercostal arteries is uncommon after fracture of the ribs. Provided the pleura has been opened at the same time, hæmothorax may develop, which may be especially extensive if there is some injury to the lung at the same time. However, simple division of the vessel alone may be sufficient to produce fatal hæmothorax. It is not easy to make an accurate diagnosis of these injuries, especially when the hemorrhage is internal. Sometimes the question can only be settled after extensively exploring the wound and enlarging the same. The suggestions offered

[illegible]

[illegible]

Diagnosis. [illegible] in spite [illegible] becomes worse. [illegible]

Prognosis. [illegible] the pleura [illegible]. It is impossi- [illegible] for a few days [illegible]. Generally speaking, most [illegible] subcutaneous, are of [illegible] in the chest- [illegible] illness may [illegible] although it is [illegible].

[illegible] entered the pleural [illegible]. There is always danger [illegible] reaction at first. [illegible] objects, such as [illegible] clothing. These are [illegible]

[illegible] in clean cases. Socin's [illegible] the lung is of no especial [illegible]. Of [illegible] gun-shot-wounds without [illegible] 1 died; and of 12 with [illegible] 2 died. The cases with severe injuries [illegible] which is almost double this.

Treatment. The treatment of penetrating wounds will depend on the condition present. Besides cleansing the wound and stopping the develops only after considerable time; whereas in cases in which the opening is extensive, the pleural cavity becomes suddenly filled with air and the lung collapses immediately. In cases of incomplete pneumothorax, and where there is a small opening, the corresponding lung may take part in respiration, but in complete pneumothorax the lung is no longer active. It is impossible for the lung to unfold itself and overcome the atmospheric pressure. The mediastinum may even be displaced and the heart and large vessels pressed toward the opposite side at the expense of the remaining lung. The blood-pressure is increased and respiration and pulse quickened. The lung will not be able to do the work for any length of time under the unfavorable conditions in spite of all exertion, and death will follow. Hellin, on the strength of his animal experiments, comes to the same conclusion as Hyrtl that the lung does not collapse entirely in pneumothorax, but still receives a certain quantity of air on inspiration, even when the opening in the pleura is as large as the transverse diameter of the trachea. Traube has shown that the marked irritation of the vagus, which takes place beyond doubt, is sufficient to cause enough disturbance of respiration sometimes to stop breathing in inspiration. The heart action may cease, due to reflex action, and death may follow. It has furthermore been shown that pneumothorax of the right side, with its effects, is more unfavorable than on the left side, because the extent of respiratory area shut off is greater. The experimental results correspond to clinical observations. Of 10 cases with severe clinical symptoms 7 were of the right pleura.

Pneumothorax does not develop when the parietal and visceral pleuræ are adherent at the seat of injury, or when the direction of the wound does not permit the entrance of air. This condition is more frequent than is ordinarily supposed to be the case, especially in wounds which pass diagonally through the skin and muscles of the chest. Air may enter the pleural space from the lung. This takes place especially when the lung is injured and a large bronchus damaged. König says that the lung collapses in this case just like a ball filled with air. Blood pours from the wound of the lung into the pleural cavity, and whenever any large vessels are injured hæmothorax or hæmopneumothorax and severe symptoms of pressure develop. These patients may bleed to death immediately or shortly after the injury. With these conditions present, it is impossible for the lung to fill with air during inspiration. The same applies to hæmothorax as to pneumothorax, which does not develop provided the pleural layers are adherent. When the injury is not too extensive, or when the amount of blood poured out is not too great, the symptoms may subside, although not so rapidly as with pneumothorax. Hemorrhage from the lung-tissue usually ceases within a short time provided no larger vessels have been injured, and the bronchi become plugged with coagulum. If the pleural wound is kept open in simple pneumothorax, the collapsed lung will not distend. It is, of course, possible that a certain volume of air may enter this lung during inspiration, but the amount is not sufficient, because the atmospheric pressure in the pleural cavity prevents the lung from unfolding. Whenever the opening into the pleura is closed, the lung commences within a short time, provided it has not been injured, to unfold itself and resume its function. The air in the pleural cavity appears as a rule rapidly and is absorbed without reaction. The lung distends correspondingly. Relief is obtained after a few hours and in two or three days the pneumothorax may have disappeared entirely. The hypothesis that the collapsed lung is distended by the expiratory effort of the healthy side does not seem to correspond to the recorded facts.

Besides pneumothorax and hæmothorax, subcutaneous emphysema may develop. This may be slight in extent, even with simple pneumothorax without injury to the lung itself, should the nature of the external wound prevent free exit of the air from the pleural cavity. It may become very extensive should the lung be injured at the same time and the pleura be adherent. The air in these cases is forced through the wound of the chest-wall, and when this is in any way occluded, is pressed into the surrounding tissues. As a rule this symptom is more or less circumscribed, although cases have been reported in which the emphysema extended over the entire body. It has been observed to be most extensive in stab-wounds.

Prolapse of the lung or hernia of the lung may follow injuries to the chest. This occurs chiefly with large stab-wounds, more rarely after gunshot-wounds. Omboni observed in an attempt to stop severe hemorrhages from the lung that the latter distended during inspiration, but during expiration was pressed against the wound. Weiss reports similar observations. The hernia of the lung observed by him became distended during expiration, and was less during inspiration. The least amount of resistance is at the seat of injury, and the air cannot escape rapidly enough through the bronchus, so there exists a tendency for a portion of the lung to become jammed in the wound. This is favored whenever a margin of the lung is in the vicinity.

Although the symptoms produced by injuries of the pleura alone, and those due to simultaneous laceration of the lung, cannot always be separated from each other, they will be considered separately. König emphasizes that the importance of an injury to the chest does not depend on any concomitant injury of the lung, but upon opening of the pleura. For a long time it was doubted whether the parietal pleura could be injured by itself. Recently it has been proved by experiments and by clinical observations that this may be the case. The author has been able to corroborate these statements on the strength of several autopsies, as have also Wharton and others. The parietal pleura alone may be injuried in stab-wounds, incised wounds, and even in gunshot-wounds. It is evident that injuries of this sort are more or less slanting, because the lung cannot recede quickly enough to escape injury from an instrument penetrating perpendicularly to the surface. Arnold reports an interesting case of perforation of the pleura alone by gunshot. A soldier received a glancing wound of the left half of the chest at about the axillary line. He died from pyothorax, and the autopsy showed that the lung, which was very much compressed, had been uninjured. Klebs reports a case in which a ball entered over the fourth rib and escaped over the head of the tenth rib after fracturing it. Neither the lung, pericardium, nor diaphragm, was injured.

Symptoms.—The symptoms of simple perforation of the pleura may be so insignificant that the diagnosis may not be possible. This is especially the case when air and blood are not poured into the pleural cavity, and when the external wound is rapidly closed. The picture is quite different, however, when the cavity is suddenly and extensively opened. Pneumothorax develops immediately in many cases, as shown by percussion, and is more extensive the greater the opening in the chest-wall and the longer the time that air has had free access. Although some patients are able to withstand this complication, as frequently seen during operation, others are attacked immediately by irregular respiration, which may even cease for a time or be very much interfered with. Dyspnœa develops, and is associated with a small pulse hardly to be felt, which is intermittent and increased in rate. In severe cases these symptoms may be very marked and the patient succumb almost immediately. It is very probable that this result is due to reflex paralysis of the heart and lung. In bilateral complete pneumothorax the fatal result is the immediate sequence of the condition. Hellin's experiments do not disprove this statement. Fortunately the surgeon is not often called upon to deal with these conditions. On the contrary, pneumothorax due to accidental injuries is as a rule insignificant provided no other complications develop. A portion of the air which has entered is expelled during expiration, and even if the tension in the chest becomes excessive, it is as a rule not so marked as in cases in which the lung has been injured at the same time. Any emphysema that may develop is confined generally to the margin of the wound.

Aside from the symptoms of pressure within the chest after closure of the external wound, the fate of the patient depends upon whether the pleura has been infected or not. When this is not the case, pneumothorax disappears quickly and the pressure-symptoms subside rapidly. In other cases septic pleuritis with severe symptoms develops. The amount of exudate increases, as does the fever, and, provided no vent is given through the original wound or through the incision, the heart as well as the diaphragm and opposite lung may be found displaced by the increased intrathoracic pressure, which leads to severe dyspnœa and cyanosis. These patients gasp for breath and sit upright. The chest is thrown forward, the intercostal spaces bulge, the entire half of the chest is dull, and respiratory sounds are no longer heard. The pulse is rapid, small, and scarcely perceptible.

There is more danger of suppuration when blood has been also poured into the pleural cavity so that the surgeon has to deal with a pneumothorax. It has been noted that this is usually due to hemorrhage from vessels of the chest-wall, and that injury to these itself may cause death. The author's experience has convinced him that stab-wounds and incised wounds are much less favorable, as far as infection is concerned, than gunshot-wounds, because the projectile has fewer bacteria than pocket-knives and similar instruments used for stabbing and cutting, provided, of course, that foreign bodies are not carried in with the ball.

It has been mentioned that blood which has been poured out may be reabsorbed with rapidity, because the surface of the pleura is a membrane like the peritoneum, which has properties favoring rapid and abundant absorption. Besides this, the blood remains liquid for a comparatively long time because the lining membrane of the pleura corresponds more or less to that of normal vessels.

Diagnosis.—It is not always easy to make a diagnosis of simple penetrating wounds of the chest, and it may be extremely difficult to decide whether the pleura alone or the lung has been injured at the same time. In superficial injuries to the lung a differential diagnosis is impossible. The surgeon may draw conclusions only from the absence of certain symptoms and to a certain degree from the course of convalescence. When there is no hæmoptysis, which is the most frequent, although not a constant symptom of injury to the lung, the pneumothorax disappears rapidly as a rule, and when there is only a slight accumulation of blood, or none at all, it is probable that the pleura alone has been injured. When pneumothorax increases in spite of closure of the external wound and the side of the chest becomes tense, it is almost certain that the lung has been damaged.

Prognosis.—The prognosis of simple perforation of the pleura depends largely whether infection has taken place or not. It is impossible to decide this at first, and one must always wait for a few days before expressing an opinion on this point. Generally speaking, most injuries to the pleura, provided they can be kept subcutaneous, are of favorable termination. If, on the other hand, the opening in the chest-wall has gaped for some time and become infected, a long illness may be expected, the outcome of which is always doubtful, although it is possible to do more nowadays than in former times.

The presence of foreign bodies which have entered the pleural cavity will interfere largely with recovery. There is always danger that this may be the case even when there is no reaction at first. The projectiles are not so likely to interfere as other objects, such as the points of knives, wood-splinters, or pieces of clothing. These are the chief sources of infection.

Recovery is usually a very simple process in clean cases. Socin's statistics show that simultaneous injury to the lung is of no especial import provided it is not extensive. Of 6 gunshot-wounds without injury to the lung that could be demonstrated, 1 died; and of 12 with superficial injury to the lung, 2 died. The cases with severe injuries to the lung, however, have a death-rate which is almost double this.

Treatment.—The treatment of penetrating wounds will depend on the conditions present. Besides cleansing the wound and stopping the bleeding, the pleura should be closed from without as rapidly as possible when it has been punctured. When the wound is a stab or extensive incision, it is best to suture a portion of the pleura after carefully cleansing the region. With small wounds, gunshot-wounds, and small crushes, antiseptic or aseptic occlusion will be sufficient. Incised wounds heal very quickly under firm bandage and do not as a rule need to be especially cleansed. Whenever a wound looks suspicious it is best to pack with aseptic gauze or iodoform gauze. As far as treatment of exudates is concerned, reference should be had to the succeeding chapter.

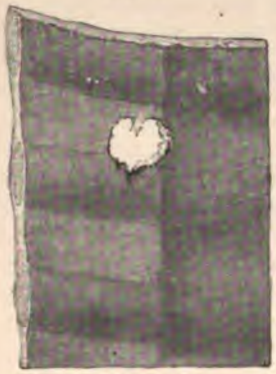
Injuries of the Lungs.—Most instruments which penetrate the parietal pleura touch the visceral pleura and penetrate into the parenchyma of the lung for a greater or less distance (penetrating wounds). Gunshot projectiles, especially those of small calibre, frequently pass through the entire lung and out the other side of the chest (perforating wounds). Not infrequently the instrument, and especially projectiles, may pass through both lungs. On the other hand, the surface of the lung may be only scratched. The clinical picture does not vary materially in these conditions. Arnold considered the latter a favorable condition, because of easy and rapid healing. The majority of injuries in times of peace are produced by knives, daggers, swords, pistol-balls, etc. Various other sources of injury have been reported, especially accidents where the offending objects were iron rods, drills, etc. In war, bayonets and the various kinds of projectiles are responsible for injuries of this sort. The lung-tissue may be destroyed to a considerable extent. Generally speaking, the damage is greater the nearer the injury to the hilus.

In many cases the ball may become embedded in the lung or penetrate the lung and a portion of the opposite chest-wall, and may oftentimes be arrested immediately beneath the skin. This is especially the case with revolver-balls. The author has repeatedly removed these from the skin adjacent to the vertebral column. Sometimes the projectile remains in a rib or in one of the vertebra, or falls into the pleural cavity after hitting a rib, so that it finally lies upon the diaphragm. After perforation of the pulmonary artery a ball has been found in the right ventricle. Whenever the projectile passes through a rib or any other portion of the skeleton, many splinters are usually carried into the lung. The track may be filled with numerous bits of bone. The chest may be perforated in any direction, but this happens most frequently from before backward or diagonally. It has been perforated from side to side and longitudinally. This is not uncommon when the firearm is discharged at a prostrate subject.

The experience with projectiles of small calibre shows that injuries to the lung are much less serious than when the old projectiles were used. Simple laceration of the lung-tissue is much more common than formerly, because the ball enters much more easily between ribs without damaging the bones. Diagonal wounds are an exception to this. The track of the ball as a rule, even when received at close range and in suicidal attempts, is rather small and with smooth walls. The results of v. Bruns' investigations and those of the Medical Division of the Prussian War Department were in agreement. Habart claims that the track was frequently difficult to find. Foreign bodies are carried into the wound much more rarely than formerly. With increasing distance there is a slight diminution in the amount of damage done to the parenchyma. The immediate vicinity is usually infiltrated with blood. The canal itself is filled with blood and the wound entrance and exit are plugged. The wound of entrance may be round or oval or slit-like. The pleura may be torn in a radiating manner. Whenever bone is injured the track is filled with fine splinters, as in a preparation of the author's. The opening in the pleura and fascia is usually large and irregular, as distinguished from the wound in the muscle.

The appearance of the wound of entrance and that of exit in the skin is as follows: in wounds at close range the neighborhood of the track is usually blackened by powder. The size of the wound of entrance does not vary much with the distance. It may be from 5.7 to 7.6 mm. with small-calibre firearms, and diminishes slightly with the distance. The wound of exit, provided there is no complication, varies in the same way between 5.7 and 9.5 mm. The wound of entrance is usually smooth and round with slightly inverted edges, while the wound of exit is slit-like or jagged with everted edges. In a suicide the author found that the wound of entrance was 7 mm. and round, that the margins were slightly inverted, and that the wound of exit, although the sternum had been injured as well as the rib, was not much larger. The margins were slit-like and slightly everted. When the ball hits the surface at an angle or transversely, the wound of entrance is correspondingly changed in appearance. This also applies to the wound of exit, which may become very much enlarged and irregular, due to particles of the foreign body, or splinters of bone or changes in the shape of the projectile. In some cases there may be several wounds of exit. The larger and more irregular the wound of exit, the more probable some damage to the ribs, the scapula, etc., although this need not necessarily be the case. The ribs are usually split and the sternum is frequently perforated. Even when only the margin is hit a more or less extensive piece is torn out leaving a gap with round, smooth edges. This portion is usually shattered and pressed into the surrounding tissue, whereas larger fragments of the ribs may be driven far into the lung. In some cases, however, the ribs may be simply perforated or gouged.

FIG. 127.



Gunshot-wound of sternum.

Symptoms.—The symptoms produced by injuries to the lung vary. They do not always correspond to the size of the injury. Some victims collapse immediately after injury. This is oftentimes only the result of shock, for they are apt to recover within a short time. On the other hand, cases occur in which there were almost no symptoms at first, the patient stating that he did not "feel anything" at the time of injury and was able to walk for a considerable distance. Most injuries to the lung are associated with marked symptoms at once. Many of the victims are no longer able to stand. They become pale, tremble, and have an anxious expression. The forehead is covered with cold perspiration, the extremities are cold, the voice weak, the lips livid, and there are distressing cough and dyspnœa. Respiration is superficial, short, and rapid. The pulse is weak and small, elusive and irregular. Many patients complain of violent pain, not infrequently in the abdomen, although there is no injury in this region. They cough blood, breathing is purely abdominal, and unconsciousness may develop in some cases. Sometimes convulsions and temporary amaurosis have been observed. (Eisenmann.)

Dyspnœa is the most alarming symptom, and may develop rapidly; it is the result as a rule of extensive hæmothorax or pneumothorax. This symptom, however, may not appear for several days, and in these cases be due to increase of intrathoracic pressure because of continued hemorrhage. Dyspnœa may increase steadily, and many wounded die as the result of compression. In other cases the marked loss of blood alone is the cause of death. Most victims succumb to hemorrhage immediately, although secondary hemorrhage may also be followed by fatal cases. Beck lost 24 of 98 cases from hemorrhage. Seventeen of these were of the lung, 6 from the intercostal and internal mammary artery and 1 from the subclavian.

Should the wounded recover from the primary shock, the clinical picture will vary according to the condition present. When the lung is adherent to the parietal pleura and no large vessels or bronchi have been injured, recovery is simple indeed. Pneumothorax and hæmothorax are absent. These conditions are probably quite frequently present, as found by Billroth in the Franco-German War of 1870–71. Adhesions between the pleuræ were common. In many cases of penetrating injuries to the lung hæmothorax or hæmopneumothorax develops. Matthiolius observed dulness 23 times, hæmothorax once, and pneumothorax 3 times. A. Hildebrandt observed 4 cases of pneumothorax and 19 of hæmothorax in 32 cases. The degree depends upon the severity of the injury whether large vessels or bronchi have been injured or not. When the opening in the chest-wall and parietal pleura does not become plugged, blood may ooze with each respiratory effort. Besides this the pleural cavity becomes filled and the symptoms of pressure already described develop.

A fact favoring convalescence is that hemorrhage from the smaller vessels of the lung usually ceases quite early, aided by collapse of the organ itself and pressure from without. Secondary hemorrhage is uncommon, generally speaking. The bronchi usually plug rapidly with blood, so that the air no longer escapes and the pneumothorax ceases to increase. Klebs claims that retraction of the elastic wall of the alveoli aids this condition. The data regarding the frequency of hæmoptysis vary considerably. It may be completely absent, as has been emphasized, but is pretty constant with extensive wounds. v. Coler and Schjerning observed hæmoptysis 8 times in 14 cases which recovered, and which were injured with small-calibre firearms (57 per cent.). This statement corresponds to the observations of Küttner and Hildebrandt. Mossakowski reports 40 cases with hæmoptysis in 43 penetrating injuries of the chest. In some cases this symptom does not persist for any length of time. According to Küttner, it may last from ten minutes to fourteen days. There is usually an annoying tendency to cough.

Emphysema is a symptom which must be considered. The author has spoken of this condition in connection with simple wounds of the pleura. He has observed that it is more common with stab-wounds than with gunshot-wounds. The frequency of this condition varies, according to different surgeons (Hennen, 1 in 50; Neudörfer, 1 in 200; in the Franco-German War, 12 in 100). v. Coler and Schjerning observed this condition twice in 22 cases; and Küttner and Hildebrandt in about 20 per cent. As a rule, emphysema is limited, although cases have been reported in which it extended over the entire body.

Prolapse of the lung or hernia of the lung is more frequent with stab- or incised wounds than with gunshot-wounds. In injuries due to small-calibre projectiles it is seldom observed, except when a diagonal wound opens up one of the intercostal spaces for a considerable distance.

In the War of the Rebellion only 7 cases of prolapse of the lung were reported due to gunshot-wound of the chest; and Morel Lavallée reports only 3 cases due to gunshot-wounds in 30 cases of prolapse; Wahl observed only 1 case in the Franco-German War. The ball entered at the level of the last dorsal vertebra, four inches to the left of the spinous process and between the seventh and eighth ribs, one-half inch outside the mammary line, and escaped. A hernia developed about the size of an apple, which increased on expiration and became smaller on inspiration. This gradually became necrotic and recovery took place after seven to eight weeks.

If there is considerable constriction, the prolapsed piece of lung becomes congested and tends to become necrotic. In some cases the lung recedes again, whereas in others it can be observed to fill with air and can be easily compressed. Not infrequently this prolapsed portion occludes the opening in the chest-wall air-tight and pneumothorax has no chance to develop, which without this accident would in all probability be present.

The clinical course of injuries to the lung varies considerably. Empyema, according to Küttner, is uncommon even with conservative treatment in injuries from modern firearms. Aside from the primary dangers already emphasized the course will depend upon the absence or presence of infection. There are two possibilities. The wound may become infected from without by the projectile, etc., or from within by the air. It is well known that the latter is an uncommon event, as shown by Hüter and König, because the air which enters is more or less filtered. The germs are apt to remain adherent to the bronchial mucous membrane. It must always be remembered that there is the possibility that some inflammatory process in the lung may have been present at the time of injury. Besides this, it may happen that suppuration takes place even when the conditions about the wound seem extremely favorable. For some reason or other this accident is apt to occur quite late. When none of these conditions is present and no large bronchi have been injured, the clinical course is usually favorable. The lung soon resumes its function. König observed in experiments in which the lung was only superficially injured that this took place within twenty-four hours. The smoother the canal, the less the number of interfering foreign bodies, etc., the more rapid this part of recovery. There are numerous cases of recovery of this sort reported, and the statements from the South African War prove that this is much more often the case with small-calibre firearms than previously. In many cases the wounded recovered sufficiently to be able for immediate service. Hæmothorax lasts, of course, for some length of time, but even complicated cases may recover completely. The parietal and visceral pleura become intimately adherent at the seat of injury. If, however, healing is interfered with, there may be superficial or deep sloughing of the bullet-track, according to the conditions present. Granulations develop and healing takes place after considerable time. The sooner foreign bodies that are present are eliminated, and the more rapidly superficial sloughing portions are cast off, the quicker recovery takes place. When the wound of entrance and that of exit are closed completely a circumscribed abscess may develop in the course of the bullet-track.

When no primary adhesions have developed and the wound has become infected either by the air or by the projectile, or by material that has been carried into the chest, the pathological processes differ materially. The extravasated blood decomposes rapidly, giving rise to a profuse air-containing exudate that may fill the pleural cavity within forty-eight hours, if not sooner, press upon the lung, depress the diaphragm, and displace the heart and healthy lung. It is frequently very purulent with a penetrating odor, serosanguinous, and is dark brown and flaky. The surface of the pleura is covered by a thick fibropurulent layer. Similar processes develop in the track within the lung, and larger and smaller pus foci appear within the organ. The injured lung may at times become gangrenous and large portions may be destroyed. When the process does not present this malignant character, which usually kills the wounded within a short time, a suppurating process may develop and empyema result. Lobular foci form and an abscess of the parenchyma may rupture into the pleural cavity, or *vice versa*. Processes of this sort may extend to the healthy lung or involve the pericardium and mediastinum. Where there is prolonged suppuration, other organs, such as the spleen, kidneys and liver, my be affected.

Recovery may take place in these cases with proper treatment. Both surfaces of the pleura become adherent to a varying extent. In chronic empyema, thick fibrous masses develop which retard recovery. Later will be considered the alterations of the thorax and the compensatory curvatures of the spine and displacement upward of the abdominal viscera, especially of the liver.

Sometimes the patients do not recover, and succumb finally to chronic suppuration. They seem to have stood the primary condition fairly well, although they become infected later by tubercle bacilli. Recovery is influenced by the presence of foreign bodies. It is well known that these may become encapsulated within the lung. They must have been more or less sterile, otherwise they would have produced general or local infection. The consistence of these foreign bodies is of some influence, because bullets and similar bodies are very apt to become encapsulated, whereas vegetable substances are usually cast off, and animal substances are dissolved or attacked and removed by phagocytes. New tissue develops around the foreign bodies during the process of encapsulation. If, however, leucocytes can penetrate the substance, the latter may succumb to the attacks of these cells. The tissue in which the body is lodged is of importance, because the lung and pleura especially are extremely tolerant. Although some foreign bodies, especially bullets, may heal up within the lung and never produce symptoms, they are always a danger and frequently give rise to severe disturbances, such as circumscribed or diffuse empyema, later when they have been forgotten. Cases have been reported in which foreign bodies have been coughed up after many years. There is no doubt, as recently proved by Brunner and Grätzer, that bacteria which have entered a foreign body may remain *in situ* for a long time without giving rise to symptoms, and then suddenly show their virulence for reasons which are unknown. These are not cases of reinfection, but are due to the development of the latent pathological properties of encapsulated organisms. The author removed a piece of lead from a patient that had been shot in the back in 1866. The bullet had given rise to no symptoms for twenty years, but suddenly caused marked suppuration. It has been demonstrated experimentally that bacteria which enter with a bullet are not killed by the heat of the projectile. The fact that bits of clothing which contain abundant bacteria, as shown by Karlinsky, may enter with a bullet needs but to be mentioned. The bullet itself may be contaminated while passing through the clothing. The author's experience seems to show that bits of clothing are the most dangerous foreign bodies that may enter the wound, because they produce some reaction, not immediately, but later. Demme's statistics are extremely interesting. Of 102 gunshot-wounds of the chest with two openings, 45 died. Of 57 in which the projectile lodged within the body, 52 died. The percentage of recoveries, even in time of peace, is low. Bland found that out of 36 revolver-wounds, only 1 of 15 perforated cases died, whereas 5 of 21 penetrated cases succumbed. Berthold found only 3 cases in which the projectile became encapsulated in 121 injuries of the chest, and Mossakowski emphasizes particularly that those cases of injury to the chest were especially unfavorable in which the projectile remained in the body. The author could report a number of cases in which revolver-balls remained within the chest cavity without damage, although there were at first grave symptoms. Geiger reports a case in which a soldier joined his regiment after five days and coughed up the bullet three years later during an attack of pneumonia. Weiss reports a case in which a man was shot twenty-five years before the date of his death. He succumbed to severe hemorrhage from the lung, and the autopsy showed that the ball was contained in an abscess cavity which connected with a bronchus.

Although at the present time surgeons are able to locate most foreign bodies in the lung by means of the radiograph, it is a very different matter to find them. Tuffier reports only 2 recoveries out of 11 operations. Christovitsch was able to remove a bullet with the surrounding necrotic parenchyma. The projectile presented in the empyema cavity, which had been opened six days after the primary injury. Projectiles of small calibre rarely remain within the chest, so that the prognosis is much more favorable than in former times.

The process of healing in the pleura and lung has been accurately studied experimentally and clinically. It has been shown that repair is simple provided there is no complication. König observed in his experiments that wounds of the pleura and lung became glued together very rapidly by fibrin, and that connective-tissue adhesions developed within a short time. When the fibrous deposit was removed, it was found that the wound in the lung had been closed. On forcing air through a bronchus into the lung it was found that the wound did not leak in the least, and closure was so complete, even after removal of the occluding material, that the lung usually burst at some other point when air was forced in under pressure. The wound is also closed by the aid of hemorrhage into the bronchi. Hadlich studied the finer processes of the tear of the lung and pleura with great care. His experiments refer only to uncomplicated wounds. He even avoided pneumothorax. Several animals whose lungs Hadlich injured died from hemorrhage; in others the amount of bleeding was insignificant. This author found that with injuries of the lung the margins of the incision heal rapidly even when bleeding within the lung persisted. The edges were slightly turned in. After three hours swollen and broken-down alveolar epithelium could be found in the air-vesicles. Small round cells made their appearance, which could easily be confounded with lymph-cells. The wounds united within a very short time, even after six hours. The epithelial and round cells become very abundant at this period, and the latter infiltrate the surrounding tissue, especially the alveolar septa, and follow along the course of the vessels. They may even infiltrate their walls and occlude the lumen of small arteries (white thrombosis, Zahn). The larger arteries remain patent, although the walls show unmistakable signs of inflammation. The epithelial cells not infrequently contain from three to four nuclei. Whenever a bronchus has been injured, it remains open up to the place where coagulation has taken place. As a rule only a small quantity of coagulated blood is contained and the bronchial epithelium is swollen. There is round-cell infiltration in the vicinity of the pleural wound and the endothelium is swollen. After three or four days spindle cells are present, and on the sixth day a connective-tissue scar is developed in slight cases of injury. This takes somewhat longer with more extensive damage. Later cavities develop in the scar which contain air. These appear to be produced mechanically by the action of the adjoining and communicating bronchi. This would seem to be borne out by the fact that when they are close to the bronchi they are lined with the same sort of epithelium. The scar finally becomes quite firm and more dense than the surrounding lung-tissue.

Divided bronchi may unite again completely and retain their lumen provided there is no displacement. Obliteration was never noted. The alveoli in the vicinity of the wound resume their normal appearance in the course of time. The inflammatory processes are not extensive, although they are somewhat more marked than is usual in soft parts. Aspirated blood is of no importance if in contact with the air of the bronchi and not in direct contact with the air of the wound. This is further proof of the view that the air is more or less filtered in its passage through the bronchi. Examination of the parietal pleura showed that there was considerable separation of the wound. The intervening substances were serofibrins and recovery took place as in other soft parts. Hadlich did not observe adhesions between the two pleuræ and pseudomembranous bands were present in only 4 cases. The plugs of exudate situated on the pleura soon show evidence of organization, and it is not improbable that the epithelium partakes in this process.

Hadlich's results correspond to the statements of Klebs and Arnold. It is astonishing how rapidly recovery takes place after gunshot-wounds. The organ is a soft elastic tissue which closes the track immediately, provided there has not been extensive loss of substance. It is not an especially favorable medium for inflammatory processes. The track of the bullet is still further closed by the pressure on the organ due to pneumothorax. Besides this the surface of the wound becomes covered with fibrin and the canal itself filled with blood-clot. Very little air escapes from the alveoli. The immediate vicinity is infiltrated with blood, sometimes more, sometimes less, according to the amount of injury and the vessels injured. When there are no foreign bodies in the canal, primary healing may take place with but very slight new formation of tissue, which differs as far as the process is concerned in no way from the tear of other tissues. The blood becomes absorbed or expectorated and round-cell infiltration occurs, followed by scarification, so that it is difficult later to detect the seat of injury. The amount of laceration around the wound of exit is more pronounced than around the wound of entrance. The result of experiments and the experience with small-calibre firearms seem to be harmonious.

The statistics on injuries of the lung show great variation as regards frequency and death-rate. To enable correct judgment, one should, of course, include the cases that die immediately after injury or within a short space of time. Those cases that reach a hospital have already passed the chief danger—primary hemorrhage. Löffler tried to correct the errors in statistics, and noted the seat of injury of those left on the battlefield and those that died within the first twenty-four hours. He found 27 per cent. of 469 deaths due to wounds of the chest. The absolute death-rate of gunshot-wounds of the chest in 1864 was 68 per cent.; 46 per cent. died on the field of battle, 8 per cent. during the first forty-eight hours and 48 per cent. later. Richter made the following observations in 1870 and 1871: (*a*) 93 chest-wounds out of 2600 cases during sieges, 18 of which were musket-ball wounds and 75 due to shells; 3 of the former and 33 of the latter died immediately. (*b*) 114 injuries of the chest out of 1129 cases during battle, 89 of which were musket-balls and 25 shell-wounds; 45 of the former and 10 of the latter died instantaneously. In the Crimean War the mortality in the various armies varied between 77 and 98 per cent.; in the American Civil War, 62.5 per cent. It is safe to say that about 1 injury of the chest to 12 injuries in general, and that 40 per cent. of all wounds of the chest, were penetrating, and that the total mortality is about 60 per cent. The mortality since the use of small-calibre firearms is considerably less, although no definite figures are at hand.

Diagnosis.—Although the diagnosis of penetrating wounds of the chest is not difficult, generally speaking, there are cases in which it may be very difficult at first to decide just what the extent of the injury is. It is not easy to state sometimes whether the lung has been injured or not. In some cases this is absolutely impossible. Not even the course of recovery will enable any definite statement. This applies especially to the injuries from small-calibre firearms. If there are a wound of entrance and a wound of exit, and the direction which the projectile took corresponds to the position of the lung, especially if the ball struck at right angles to the surface, one will as a rule not make any mistake in assuming that the lung has been perforated. It has been mentioned that it is easy to be deceived in the upper lateral regions of the chest. The ball may pass through the base of a conical mass of soft parts outside of the pleura, especially if the arm is raised. The impression is that the bullet has passed through the chest cavity. Hæmoptysis, which in some cases is profuse, may be considered a very valuable and almost constant sign of injury of the lung, although it may be absent even when the amount of damage is very great. The tendency to cough, which tortures the patient extremely, is also a valuable sign. Whenever the wounded become rapidly pale or the lips cyanotic, the eyes protruding, the extremities cold or cramped, there is usually severe internal hemorrhage, provided there is no shock, from which the individual soon dies. The author has repeatedly emphasized that it is extremely difficult to decide whether the hemorrhage comes from the chest-wall or from the lung itself. The presence of foamy blood in the wound in the chest will indicate injury of the lung. It has been demonstrated that severe hemorrhages usually result from injury to the pulmonary vessels, and that the internal mammary and intercostal arteries always bleed through the external wound as well. In favor of simple penetrating wound—*i. e.*, opening of the pleura—would be the entrance and exit of air through the wound in the chest-wall on inspiration and expiration, pneumothorax and emphysema, especially if the air has not free exit, either on account of the diagonal direction of the wound or due to rapid plugging of the same. The absence of pneumothorax does not indicate that the pleura has not been injured. It may even be absent when the lung has been injured, which is the rule when there are adhesions between the pleura. The sooner hæmothorax disappears after closure of the external wound the more probable it is that the lung was not involved. For this reason tense pneumothorax which continues to increase and produce symptoms of pressure and dyspnœa in spite of closure of the external wound, indicates laceration of the lung itself. Extensive emphysema is of similar significance, because with simple wounds of the pleura under favorable conditions this symptom is usually limited. Microscopical examination of the sputum may give a certain amount of information. Dollinger was able to demonstrate bits of cloth in one case and the white blood-cells contained in the sputum showed blue pigment, which was derived from the uniform.

Prognosis.—The prognosis of penetrating wounds of the chest will be evident from the above statements. It is impossible to make any definite statement, because the observations vary so greatly. The statistics of the different wars would really be of value had all injuries to the chest been made note of and whether the soldier died immediately or was subsequently treated. It has been shown that a large percentage remained on the field of battle; 117 of 254 died immediately. A certain number die on the way between the field of action and hospital, and only the remaining wounded come under medical observation. Besides this, injuries to the mediastinum and the important organs contained therein, and the complications due to injury of the abdominal viscera, ought to be left out of consideration. The prognosis, however, of gunshot-wounds of the lung with modern firearms is rather favorable. The experience in peace and during the recent wars bears out this assertion. Strehl reports that all 12 gunshot-wounds of the lung under his observation recovered. He did not observe any infection. Ringel reports that the 17 patients which he treated all recovered. Some of these were ready for service eighteen days after injury. The chances for recovery for those that come under treatment is far greater than formerly. Many wounded will die immediately after injury on the field of battle, due to hemorrhage. This is especially the case when the lung is perforated near the hilus and some large vessel has been damaged. The modern projectile has the peculiarity of cutting the vessel-wall much cleaner than the old bullet, which causes much greater and more prolonged bleeding. This unfavorably affects the prognosis. Although the death-rate of 12.5 per cent. observed by v. Coler and Schjerning during peace with a 8 mm. projectile will in all probability never be reached on the field of battle, still the percentage will be far more favorable than formerly, because the wound is inflicted from a greater distance and bone-splinters and other material will not be carried into the lung so frequently. Cases have been reported in which both lungs were shot through and recovery was uninterrupted. Only 1 case of empyema has been observed of 14 cases of gunshot-wounds that recovered. (v. Coler.)

The fact that the modern projecticle does not often remain in the lung is of favorable significance. Almost always the bullet traverses the chest, and most of the bullet-tracks are comparatively aseptic. Matthiolius mentions that only 5 bullets remained in the body out of 45 perforating wounds. This accident, as has been seen, may become very annoying. There are, however, many cases in which the projectile has healed up in the lung without producing any symptoms whatever. The cases resulting fatally immediately are much more uncommon than formerly. For evident reasons the injury in times of peace is much more favorable than in war.

Injuries to the hilus are especially dangerous. The farther away from the root of the lung, the more favorable the wound, because in many cases only small bronchi are divided and there is no hemorrhage which endangers life. If the patients survive the primary dangers, chief of which is hemorrhage, the subsequent course of convalescence will depend on whether the wound has been infected or not. The symptoms due to infection will control the situation. If no infection has occurred, even severe laceration of the lung may heal without reaction. Perforation of both lungs and simple accidents may recover completely. Velde reports a case which recovered where a 12 mm. bullet opened the thoracic cavity sufficiently to allow considerable pieces of lung-tissue to be discharged through the wound. Formerly a large number of wounded died of empyema, whereas at the present time surgeons are much more able to cope with the situation. Quite a number of these cases may be saved by operation. In individual cases comparatively late secondary hemorrhage has resulted fatally.

It is necessary to observe the patients for a considerable length of time before making any statement about the final result in any individual wound of the lung, for it has been shown that many wounded that were discharged well suffered later from the results of that injury, or died. Berthold's communications are of especial value because they take into consideration the subsequent fate of the injured individuals.

Treatment.—Treatment of injuries to the pleura and of the lung includes: first, care of the wound; second, treatment of the primary symptoms produced by the injury; and, third, treatment of the late symptoms. The author has already expressed himself regarding the principle of treating the wound in connection with non-penetrating injuries. He refers therefore to what has been said in this direction and emphasizes that one should avoid examination with fingers or probes. As a rule one achieves nothing. In spite of all care damage may be done. This was probably the case without doubt in many wounded individuals in the pre-antiseptic period. Bullets that are situated immediately beneath the skin can be removed at once. The author does not hurry in these cases and has removed the projectile repeatedly after considerable time has elapsed. The wound should not be hermetically sealed by suture, as recently recommended by Langenbuch. In the American Civil War no favorable results were obtained with hermetically sealed wounds. Of 27 cases which recovered, the lung had not been injured in 20. In 42 cases that died, the lung had been wounded in all but 15 cases, and only 30 cases lived seven days. Biefel lost a patient in whom the wound of entrance had been sutured. The thorax became very much distended, perforated in spite of suture and compression, and discharged air, pus, and clots of blood through the wound. There is no doubt that closure of the wound is the best way of favoring repair, although it is not necessary to suture. Antiseptic closing is quite sufficient. It is to the credit of v. Bergmann and Reyher to have demonstrated that very favorable results are to be obtained in this way even under the most unfavorable conditions. Habart obtained very favorable results by antiseptic occlusion of the wound and packing the track with iodoform gauze. In some cases the anæmia and pressure-symptoms were severe at first and collapse was marked in one case. The author has seen very severe injuries with marked hæmoptysis and extensive hæmothorax recover completely with antiseptic occlusion. One must not be alarmed by the early threatening symptoms. This experience is common to many surgeons, and corresponds to the observations of Küttner in the South African War. Absorption of fluid material may take place very slowly. Even in penetrating, incised, and stab-wounds the author does not close the wound completely by suture. Especially in these cases the instruments which inflicted the wound are apt to be infected much more frequently than bullets. In these cases simple occlusion without suture has been of valuable service. The chief aim is to shut off the pleural cavity from without, which is best done by very careful bandaging. The author does not approve of immediate closing of stab-wounds by means of sutures, although the possibility of disinfecting gives more favorable chances. The entire canal, however, cannot be laid open. When the external wound is extensive, it is well to close a portion of the same after previously cleaning. If these wounds, however, look somewhat doubtful when coming for treatment, simple antiseptic packing should be sufficient. It is best to use large strips of adhesive plaster on the chest because the dressing is apt to slip. Even if the overlying bandage does become displaced, the wound itself stays covered. The greatest possible amount of attention should be paid to wounds of the chest after the first dressing. The pulse and temperature should be carefully controlled. If fever, pain, and difficulty in breathing indicate some inflammatory process in the interior of the thorax, the bandage should be changed, any sutures removed, and the wound drained if necessary. The author has repeatedly observed that superficial suppuration of the wound of exit and wound of entrance is of no great importance. Küttner observed symptoms resembling those of pneumonia. He explains these as being due to the absorption of blood in the lung. Pneumonia cannot be excluded, however, in certain cases. The rise of temperature observed in some cases of hæmothorax does not necessarily indicate that the contents of the pleura have become infected.

If there has been severe hemorrhage immediately after the injury, especial attention should be paid to this matter. When bleeding is from the vessels of the chest-wall, the artery should be tied or packed. When the hemorrhage, however, comes from vessels of the lung, the conditions are more unfavorable. Injuries of the large vessels of the lung never come for treatment because the majority die immediately. On the other hand, superficial injuries of the parenchyma produce no great amount of hemorrhage as a rule and cause no special symptoms. Besides this, hemorrhage from the parenchyma of the lung usually ceases spontaneously, provided no large vessels have been injured. Aside from the vessel itself, power of contracting, collapse of the lung, and pressure due to the accumulation of air and blood in the pleural cavity favor this end. In many cases bleeding persists and severe symptoms are produced due to pressure upon the heart and both lungs. The author wishes to mention that in all of these cases subcutaneous injections of morphine give most favorable results. Absolute rest in bed and cool drinks are indicated. Prolonged transportation is always dangerous. Ice-bags should be used externally. Whether ergotin is of value given internally or subcutaneously is doubtful. Whenever the symptoms of pressure become alarming, it is well to remove the blood by aspiration. At first only a sufficient quantity should be removed to alleviate the threatening symptoms due to pressure. Rapid absorption usually follows this step. If necessary, aspiration may be repeated at intervals.

The question when aspiration should be done or whether it ought to be done cannot be answered definitely, for the author has seen some patients take care of a very marked hæmothorax. It may occur, however, that the patient dies due to cessation of the heart action which might have been avoided by aspirating at the proper time. The amount of fluid drawn off at first should not be too great, because there is the possibility that bleeding may commence again, especially if aspiration has been necessary shortly after the injury, when the vessels have not become thrombosed or not firmly so.

Forced aspiration should be avoided in all cases. The seat of puncture will depend on the conditions present. It is best to aspirate in the fifth or sixth intercostal space in the axillary line. One should first explore with a fine hypodermic needle. Küttner does not recommend aspiration, and Dent has seen empyema develop subsequently. It is evident that this operation will not be completely satisfactory to the operator, although the results may be favorable at times. The surgeon always endeavors to find the bleeding point and tie the vessel. This is, however, impossible for technical reasons in the majority of injuries to the lung. Hemorrhage from the margin of the lung may be checked by transfixing and tying off *en masse*, as shown by resection of new growths. This form of injury, however, is not often associated with any great amount of bleeding. W. Koch recommends hunting up the root of the lung and tying the bleeding point by passing a ligature around with a needle. This has, however, never been done as yet. v. Omboni attempted to attack a bleeding lung itself, but the patient died. Küttner reports a case in which continued hemorrhage gave rise to severe pressure-symptoms. The seat of hemorrhage could not be found and the patient died after two days. Tuffier reports a number of cases in which success followed cleaning out the hæmothorax and tying off the lung around the seat of bleeding. He considers that it is justifiable to clamp temporarily the pulmonary vessels. Michaux resected the seventh and eighth ribs and emptied a clot of blood from the pleura in a case of severe hemorrhage after a revolver-wound. The wound in the lung was near the root and was packed. Two drains were left in the pleura. The case suppurated, but eventually recovered.

The indications in the individual case will decide which wounded are to be treated in this radical way, for it is not reasonable to expose the lung immediately as a matter of principle. It is well to wait for a certain length of time and only make an attempt to find the bleeding point when the anæmia becomes severe on account of prolonged bleeding. The author has emphasized that even severe hemorrhages are apt to stop of their own accord. If it is not possible to stop the bleeding with sutures or by tying off the surrounding lung, the track should be packed with iodoform gauze, a measure that has frequently given the desired result.

The treatment of the prolapsed portion of the lung will depend upon the condition of the portion presented. In recent cases in which there is no marked disturbance of circulation and no sign of infection, it is best to cleanse thoroughly the protruding lung and its surroundings and replace the same with the necessary precautions. It is never necessary to enlarge the wound. The portion of lung should first be compressed so as to expel the air contained, and the tissue is then pushed back into the chest cavity during deep inspiration. If the lung is injured, which is not uncommon, it is best to make use of deep catgut stitches, so as to prevent hemorrhage. Superficial stitches always tear out. With a little care the hernia may be reduced without allowing air to enter the pleural cavity and produce secondary pneumothorax. If there is danger that this may take place, it is best first to cover the protruding lung with a piece of disinfected rubber tissue. The cases reported by Scharf, Barbieri, Heider, Adler, and Sanberg show that immediate reduction of the prolapsed portion is good treatment. Klopotowsky, Völkel, and others observed that the prolapsed portion becomes reduced of its own accord at times, which led Stromeyer and Pirogoff to consider replacement or resection of the hernia counterindicated. Resection of prolapsed lung, however, either recent or when gangrenous, has been successful. Whenever there are disturbances of the circulation or when the prolapsed portion has become infected, the author considers it best to pass a ligature around the prolapsed portion and wait for necrosis. Kirchhoff first diminishes the size of the wound with sutures and then ligates. Rintelen and Grusinow have had good success with ligation. Caudy found that only 2 cases out of 14 in which the gangrenous portion had been resected died. There are many ways, therefore, of arriving at the desired end, and prolapsed lung is not to be considered an especially unfavorable condition.

It will rarely be necessary to treat the pneumothorax itself. Whenever a considerable amount of air produces threatening symptoms, aspiration may be done with advantage. König recommends incisions and drainage in some cases in which aspiration does not give the desired relief. The author does not consider it wise to replace the air by some sterile fluid. It is equally uncommon to be obliged to attack an emphysema itself, because the cases in which the air has extended over the entire body have recovered. Antiseptic packing, as a rule, soon allows the emphysema to disappear. In a few cases it has been necessary to aid recovery by multiple small incisions. König recommends deep incisions, and claims that this method has saved life in individual cases.

As far as the treatment of the subsequent symptoms due to purulent processes is concerned, it is necessary to perform thoracotomy —*i. e.*, removal of the exudate—as soon as possible. When a wound is situated low down on the chest, it may be possible to reach the exudate by enlarging the opening and draining the cavity. The drainage should be very complete and counterincisions should be made if necessary. König advises that these counteropenings should be made over the point of a sound introduced through the first wound as a guide. In empyema, where there may be considerable displacement, this is especially indicated, because it is otherwise possible to injure viscera that have become displaced. When this is not possible, an incision should be made in the ordinary way. König has had good results in suppurating processes by draining in this way and washing out with antiseptic solutions. He prefers solutions of corrosive sublimate. Personally the author believes that sterile water or normal salt solution is quite sufficient. The cleaning of the pleural cavity is a simple mechanical process. The infected tissue cannot be sufficiently impregnated with antiseptics to sterilize the region. The best method of disinfection is to remove the exudate thoroughly. Washing out is indicated only in empyema, and one should always remember that damage may be done if great care is not taken. This applies to any washing of the pleura, because, aside from the poisonous action of any fluid used to wash with, the reflex action of the fluid, especially if used under high pressure or at low temperature, must be considered.

Here will be given only a few remarks bearing on the technic of thoracotomy, and the details later. It is best to make an incision in the fifth, sixth, or seventh intercostal space in the axillary line, provided it is impossible to utilize the wound of entrance. In no case is it justifiable to be guided by the area of dulness, because the diaphragm is pushed downward very rapidly and after removing the exudate may arise with sufficient rapidity to close the wound in the thorax. An incision should always be preceded by exploratory puncture. If thoracotomy is to be done without resection of the ribs, an incision is made about 5 cm. long through the skin, fascia, and muscles down to the pleura, keeping as close as possible to the upper margin of the lower rib, so as to avoid injuring the intercostal artery. As a rule, the author prefers to puncture the pleura with a director. The fluid runs out in the groove immediately. After a little while he dilates the opening with a knife, forceps, or some other instrument and avoids making the opening larger than necessary to admit a large-sized drainage-tube. This should have several openings and need not be especially long, and should be held in place with a safety-pin. If it is desirable to wash out the cavity, a double tube may be put in place, consisting of two tubes tied together.

If it is necessary to resect a rib, which is always to be recommended, the technic is about as simple as with intercostal incisions. An incision is made under the sixth or seventh rib for about 6 to 8 cm. The periosteum is removed upward and downward by means of an elevator and lifted from the posterior surface of the rib. After preparing the bone in this way, about 4 cm. is removed. The pleura is then divided exactly in the middle line of the rib. It is well to have the patient so placed that the opening in the chest is as low down as possible, so as to favor the exit of pus. Schede recommends resection of the ninth and tenth ribs outside of the long muscles of the back, because this gives better drainage subsequently.

In many cases recovery takes place quite quickly, and the lung begins to perform its normal function again. It gradually distends and fills the pleural cavity and the normal relations are restored, although the pleuræ are adherent. König observed that a lung began to functionate again after five or six days. In other cases it is far more difficult and the empyema becomes extremely chronic, the affected side becomes retracted, the diaphragm is pushed upward, the healthy lung displaced, and curvature of the spine develops. The chances of a favorable result are therefore much less than in the acute cases. In spite of the opening the empyema cannot be made to heal. In these cases a thoracoplastic operation or surgical immobilization of the thorax is the only way of aiding the process. This subject will be returned to later in considering operations for the empyema.

Injuries of the Pericardium.—For a long time simple lacerations of the pericardium were considered to be impossible, just as in the case of the pleura. Although the heart muscle is injured as a rule at the same time, there are a number of undisputed cases which have been demonstrated on autopsy as well as by operation. Fischer collected 51 cases. It must be acknowledged that some of the diagnoses which could not be corroborated in any way are to be doubted, but it must be recognized, just as in the case of the pleura, that this type of injury does occur. It may be due not only to stab-wounds and incised wounds, but even gunshot-wounds have been known to be the cause. It is known that the pericardium has been torn by splinters of ribs and by needles that have penetrated the chest-wall. Eichel has recently collected the cases of simple gunshot-wound of the pericardium in connection with a case of his own. Aside from 19 cases in which this condition was probable on account of the clinical course, he reports 4 cases with autopsy and an equal number in which operative interference had been resorted to. Simple laceration of the pericardium by small-calibre bullets has not been reported. The position of the heart is such that the pericardium or the heart itself is rarely injured without damaging the pleura at the same time. Anatomical investigations have shown that the relations of the pleura to the heart may vary considerably, and that it is only due to coincidence or accident that the pleura is not injured. Only in exceptional cases is there a small place not covered by pleura. Sick found on investigating the situation of the margin of the left pleura that at the level of the seventh rib this fold was 2 cm. distant from the margin of the sternum in only 20 per cent. of the cases. Tanja has shown variations which prove that the pleura may not be injured in one case, whereas in another it could not possibly escape. It is impossible to tell beforehand what might happen. It should not be forgotten that the relations may be changed by hæmopericarditis or inflammatory processes. In these cases the pleural cavities are separated from one another, as has been repeatedly demonstrated.

Symptoms.—The symptoms and the course of injuries to the pericardium may vary considerably. If there is simple perforation without much hemorrhage into the pericardium and no inflammation, the clinical picture may be simple indeed, and recovery takes place within a short time. A large number of cases have, without doubt, healed in this way without the diagnosis having been made. In some cases the heart action is considerably increased. The pulse becomes rapid and there may be friction-sounds. Even when there is pericarditis, provided that the exudate is not excessive, or with pleuritis, as in Bamberger's cases, recovery may take place quite rapidly. There must be, of course, no purulent or septic process. Pericarditis, as emphasized by von Eiselsberg, may develop quite late after the primary wound has apparently healed. In his case signs of septic pericarditis developed one month after the injury, when the original wound had completely closed. The pus contained *Bacillus coli communis*. It is quite possible that the late infections may take place through the blood-current.

The conditions are quite different when there has been extensive extravasation of blood into the pericardium. This rarely takes place secondary to injuries of the pericardium itself; so as a rule there are complications which alter the clinical picture materially. In all of the cases in which there has been an extensive accumulation of blood severe and characteristic symptoms develop which will be considered later in connection with injuries of the heart itself. The heart action is increased, becomes irregular and intermittent. There is threatening dyspnœa, and death not infrequently follows in a short time. It is very evident how much damage fluid in the pericardium may do to the heart and its function when it is seen how great the relief given immediately as soon as the bloody exudate is removed. The breathing improves shortly and the pulse becomes quiet and slower. Most of the wounded individuals who might have survived the hemorrhage itself die on account of the pressure exerted upon the heart. Fortunately marked effusion of blood into the pericardium without any other injury except of the pericardium is uncommon. Whenever there is much bleeding, the heart itself has been injured as a rule or some vessel of the lung or chest-wall. The pericardium is quite able to take care of a certain amount of blood, although the heart action may be more or less accelerated for a considerable time on account of the remaining adhesions. It is remarkable that foreign bodies of considerable size may remain in the pericardial cavity for years. Quite a number of cases of this sort have been reported. Should there be infection of the pericardium, there will be marked symptoms of intrapericardial pressure, a small pulse that can hardly be felt, and severe dyspnœa, which the patients cannot bear for any length of time. Sometimes there is very extensive exudation on account of the simultaneous injury of the pleura, which in itself is of grave significance and a complication which is perfectly capable of causing death in itself. There is usually very high fever.

Diagnosis.—As a rule it is not possible to make an absolute diagnosis, especially in the early stages. In some cases the late symptoms will indicate the condition present. It is rare to have no blood whatever in the pericardium when this sac has been injured. In almost all cases there will be a certain amount, although it may not be sufficient to increase the area of cardiac dulness. Blood in the pericardium and the position of the external wound are the chief points to be considered in the diagnosis. The heart-sounds at times can hardly be heard or appear very distant. In other cases they may be perfectly clear. Not infrequently there is a distinct friction-sound. It must be taken into consideration in the diagnosis that injury of the pleura may give rise to pneumopericardium, as in a case reported by Ewald and Happel. In these cases the percussion-note will be tympanitic, although this sign is by no means so reliable as the other symptoms already mentioned. A friction-rub, which develops in the region of the heart after an injury, is almost an absolute indication that there has been some damage to the pericardium. Frequently from the nature of the injury the diagnosis may be made on inspection. Bamberger was able to palpate the heart through the wound with his finger. This made the diagnosis easy, but it is impossible in the majority of cases.

Prognosis.—The prognosis of injuries of the pericardium is not extremely unfavorable. Fischer has collected 22 recoveries in 51 cases. In only 3 cases was the diagnosis confirmed by autopsy. If, however, the number of injuries to the heart itself that recover are included, the percentage is more favorable, and in all probability about 3 out of 10 recover.

Treatment.—The treatment of injuries of the pericardium has of late years ceased to be absolutely symptomatic, although interference should be resorted to only for distinct and urgent reasons. In a certain series of cases operation has been extremely successful. In a large number of injuries, however, symptomatic treatment will be sufficient in spite of the violent early symptoms. The first duty consists in stopping the hemorrhage, and then an effort must be made to limit as much as possible the pressure made by hemorrhage upon the heart itself. If the bleeding is from the pericardium alone, it is best to keep the patient perfectly quiet, use an ice-bag, cool drinks, and morphine. Relief will be obtained not infrequently after a few hours. The greatest danger is thus over, and it is probable that bleeding has ceased and that recovery will take place. If, however, the signs of hemorrhage continue, and the symptoms of effusion of blood into the pericardium become threatening, especially if there is an increase in dyspnœa and the pulse becomes bad, then it is in all probability that the heart has been injured and operative interference—pericardiotomy—is indicated. Puncture and aspiration are to be avoided considering knowledge regarding the position of the heart and the quantity of fluid in the pericardium.

The author agrees with Eichel that the external wound is included in the field of operation. In a case of pericardial exudate after a gunshot-wound he performed pericardiotomy on the tenth day with success. A flap was made with its base toward the right side and about 2 to 3 cm. of the sternum were resected, beginning at the junction of the fourth rib. The cartilage of the rib was divided with a knife. Eichel claims that it is immaterial whether the sternum or the ribs are resected, or whether the resection is permanent or temporary, if a sufficient opening of the pericardium is obtained. It is well not to perform any typical operation, but to be guided by the seat of injury and the outline of the dull area. The seat of operation should be as low down as possible, so as to give the most favorable position for drainage. Should one not be inclined to be guided by the opening of the wound, which is as a rule the best guide in any given case, it may be well to perform simple pericardiotomy by resecting the fifth and any other cartilage of the left side for a sufficient distance. The internal mammary artery can be easily ligated, and it is easier to avoid injuring the pleura. It is not necessary to resect the sternum. Incisions in the intercostal space or along the costal arch have been generally abandoned. It is impossible to get a sufficient view of the field of operation. The suggestion of Voinitch and Sianojentzky, to adapt the method of pericardiotomy to the amount of exudate, does not seem to the author rational, because there is no method of determining the quantity.

In Rieder's and Körte's cases it was sufficient to enlarge the original wound. In Seydel's case the pericardium was exposed after laparotomy through the peritoneal cavity. The ball had entered the pericardium through the diaphragm and then passed on to the left lung. After enlarging the diaphragm opening, the opening in the pericardium, which was about the size of a pea, was dilated. The laparotomy-wound was closed as well as the opening into the diaphragm, and the wound in the pericardium drained with a piece of iodoform gauze. Symptoms of compression of the heart soon developed on account of plugging of the opening in the pericardium, which disappeared, however, just as soon as the packing was removed. Neumann enlarged his stab-wounds and drained the pericardium successfully. Although the percussion-note was tympanitic, there was only blood in the pericardium.

Riedel performed pericardiotomy on the eighth day on account of pericarditis following a gunshot-wound. The patient died two days later. Autopsy showed that the projectile was lodged in the posterior part of the pericardium and that the heart itself had only been contused. The opening into the pericardium was found already closed, so that the membrane had to be freely incised. The pericardium was about 0.75 cm. thick in some places. After opening, a serosanguinous fluid squirted out which was under considerable pressure. The fluid was frothy on account of the air that entered and the rapid action of the heart, and this foam covered the entire field of operation. The heart gradually came forward and the wound was left open and packed.

Körte opened the pericardium for the purpose of cleansing and packed after a gunshot-wound of the anterior of the chest-wall. The wound granulated and complete recovery took place. Bardenheuer was not able to find the wound of the pericardium on operation. He suspected that the diaphragm had been injured by a gunshot-wound on account of prolonged violent vomiting. The patient died on the fourteenth day. On autopsy the ball, which had entered in front, was found in the posterior wall of the left ventricle immediately behind the posterior flap of the mitral valve. Parrozzani reports that of 7 cases of pericardial wounds 3 recovered after pericardiotomy.

It is an important question whether the pericardial wound should be sutured or not. The author believes that this is not advisable, and that it is best to pack and use drainage, although it cannot be denied that sewing up has been followed by rapid recovery. (Dalton.)

Up to within a short time it was believed that the exudate and the blood were situated in the pericardium behind the heart. Rehn, Schaposchnikoff, Voinitch, Sianojentzky, and Brentano claim that the contrary condition is the case, and that the heart is close to the anterior wall, which is of considerable importance in connection with aspiration. Eichel denies this on the strength of his personal observations and believes that the old view is correct. It seems to be doubtful whether the conditions are the same in all cases, although it is highly probable that the blood is behind the heart when the body is in a horizontal position. When sitting up, the fluid is more behind and inferior.

Pericardiotomy is indicated when there is some secondary exudate with high fever and its sequences. One should not wait too long in these cases because the operation may save life if done in time.

As far as the after-treatment is concerned, it has been shown that it is best not to close the opening in the pericardium. v. Eiselsberg recommends that the pericardium should be sewed to the muscle so as to protect the pleura. The cavity should not be washed out in spite of the fact that it can be done without damage. Drainage does not act well, and it is therefore best to make use of some aseptic packing, such as iodoform gauze, which is changed from time to time. Any fluid that reaccumulates may produce the usual symptoms again. The heart has recently been exposed repeatedly for the purpose of direct massage following asphyxia from chloroform.

Injuries to the Heart.—Wounds of the heart are either superficial or penetrating. In the latter case one or the other of the cardiac cavities is opened. Fischer found only 34 of the former variety out of 351 cases reported in his classical monograph. The cause of wounds of the heart varies considerably. There are stab-wounds, stab- and incised wounds, gunshot-wounds, and traumatic ruptures. Fischer's statistics indicate the nature of the injury and the region affected.

	Stabs.	Incised.	Gunshot.	Ruptures.	Total.
Right ventricle	10	85	22	6	123
Left ventricle	14	59	16	12	101
Both ventricles	4	16	4	2	26
Right auricle	3	11	2	12	28
Left auricle	...	5	1	7	13
Apex	...	12	1	3	16
Base	1	1	1	...	3
Ventricular septum	1	2	1	3	7
Entire heart	...	2	5	9	16
Right heart	...	3	1	...	4
Left heart	...	1	4	...	5
Coronary artery	1	1	...	...	2
Unknown	6	31	7	13	57
Pericardium	6	31	7	9	53
Total	46	260	72	76	454

As a rule there is only one wound in the heart. Walker reported eight different wounds, however, in one case. This patient did not die for one and a half days. All of these wounds were of the left ventricle and were sutured.

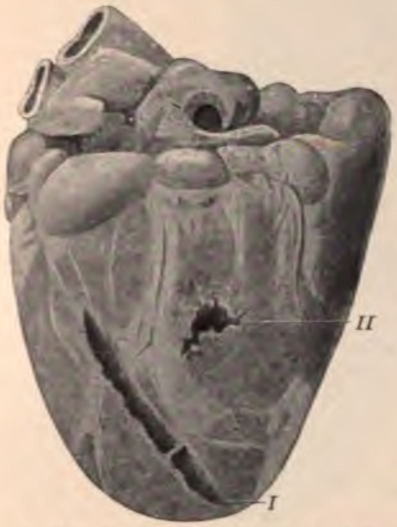
Most implements that injure the heart pass through the chest-wall from before backward, rarely from the side, and very rarely indeed from behind forward. The heart may be injured without perforation of the chest-wall; by splinters of ribs, for instance. Furthermore, foreign substances that have entered the system at some distant point may injure the heart, such as needles, which may reach the heart after years and give rise to symptoms. These have a special tendency to become lodged in the heart or lungs. Foreign bodies may perforate the œsophagus and injure the heart.

Blunt forces that give rise to concussion without producing any especial laceration of the chest or simple fractures of the ribs or sternum, may also damage the heart. The pericardium, the heart itself, or both, may be ruptured at any place except at the apex. The ventricular wall has been found perforated without other injuries. Sometimes the heart has been so much torn that it was only loosely connected with the large vessels. This type of injury is called "traumatic rupture," which is favored by friability of the cardiac muscles. This need not necessarily be the condition present, because many cases have been reported in which no such change was found. In all probability the intraventricular blood-pressure is responsible. The author will not consider spontaneous rupture in this connection. Following a gunshot-wound which did not perforate the chest-wall, Frin observed laceration of the right ventricle without change in the pericardium. The patient died in about ten minutes. Ward made a similar observation of the left ventricle, although in this case the intercostal muscles had been perforated. In Lechler's case the pericardium and left ventricle had been torn, although the bullet had not perforated the chest-wall. Settegast reports a case of rupture following a fall; Talko one after a horse-kick; and Werner that of a child thirty-three months old after having been stepped upon by a cow. In this case the left ventricle was torn but the pericardium was intact.

Projectiles may perforate the heart muscle without passing through the pericardium. Hicquet reports an autopsy of a man who was found dead with a bullet-wound in the fourth intercostal space. There was a circular penetrating wound of the right ventricle, although the pericardium, which contained liquid and coagulated blood, had not been injured. The ball was found between the pericardium and the chest-wall. Zenker, Zillner, v. Hassinger, Borellus, Heydenreich, Ward, Holmes, Gamgee, and Justi have reported similar cases, some of which involved the left ventricle. In one case the left ventricle had been injured in two places without there being any wound of the pericardium. One ball had made a groove about 5 cm. long without perforating the ventricle, and the second had made two punctured wounds. There was no blood in the pericardium. This was probably the most remarkable case ever reported. The specimen is represented in Figs. 129 and 130. It does not seem to be uncommon to have the pericardium remain intact with injuries of this sort. In the majority of cases spent balls must have been concerned which pushed the pericardium in front and ruptured the brittle heart muscle. Hicquet is of the opinion that the ball hits the heart during diastole, and that it is then thrown back during systole. However, as the apex has been found perforated and gouged wounds are also reported, it does not seem essential that the heart should be hit during diastole.

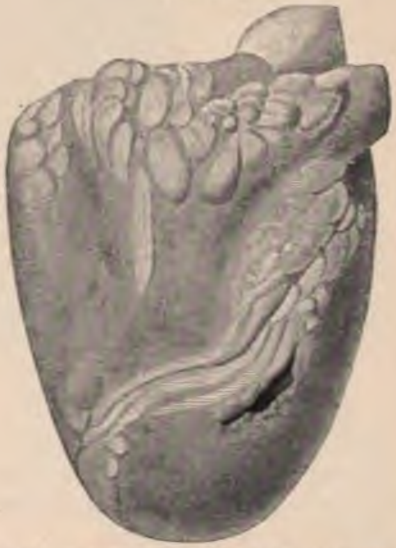
The endocardium may also be injured besides the pericardium and heart muscle. Barié has collected 38 cases of rupture of valves, 10 of which were produced by trauma. The aortic and mitral valves are most frequently affected, the tricuspid and pulmonary valves more rarely. J. Riedinger reports a case of hæmatoma of the aorta after trauma, and Flerow has observed a case of rupture of the atrium near the auricle.

Fig. 129.



Gunshot-wounds of the heart without rupture of the pericardium: *I*, graded wound; *II*, wound of entrance.

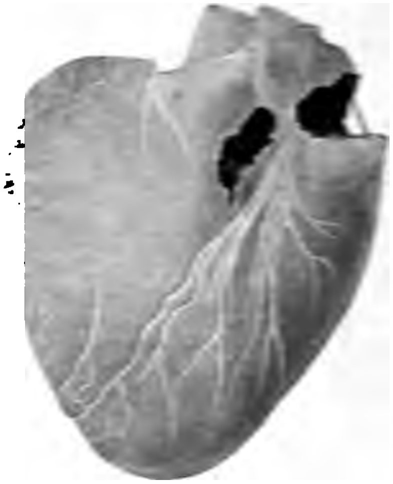
Fig. 130.



Gunshot-wound of the heart without rupture of the pericardium: wound of exit.

The heart has been almost completely severed in some cases. Small-calibre bullets have a very peculiar effect upon the heart. Sometimes only a cylindrical canal is made through the muscle. This was repeatedly observed in the South African War. In other cases the heart is completely torn to pieces. The lacerations of the heart produced by the modern English hollow-pointed projectile are very extensive, as recently shown by P. v. Bruns. This depends upon whether the heart is hit while full or when empty. In the former case the blood which is set into motion tears the heart in all directions and may even involve the neighboring organs, such as the lung and pleura. The fibrous ring between the auricle and ventricle and the valves seems to be the most resistant portion. Simple lateral tears have [illegible] After being shot with an army rifle the heart was [illegible] flattened and twisted on its longitudinal axis. The left [illegible] the pulmonary valve, and the ventricular septum had been [illegible] severed. (Fig. 131.)

FIG. 131.

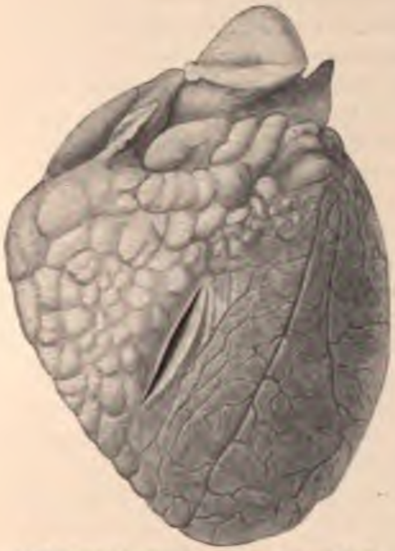


Gunshot-wound of the heart.

Symptoms.—The symptoms of wounds of the heart are not easily tabulated because specific symptoms are difficult to separate from those produced by injuries to other organs. Most of the injured individuals die in a short time from hemorrhage, although some collapse immediately.

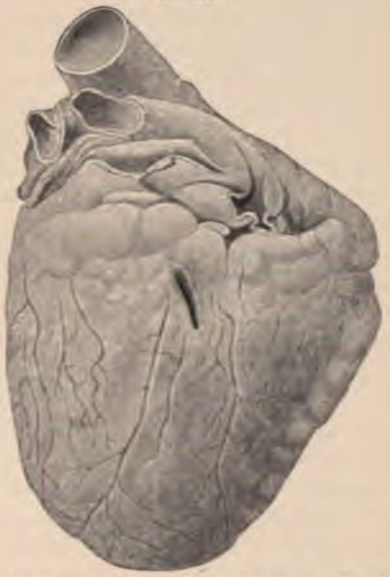
Jamain reports that 21 of 121 cases died immediately. The author considers that this percentage is too small. Only the slighter cases ever become the subject of treatment and clinical observation. Many cases become unconscious after injury. They are extremely pale on account of the lowered arterial pressure, and have pronounced anxiety which is considered almost characteristic by some authors. The breathing is superficial, labored, rapid, and noisy, and the patients become cyanotic on account of congestion of the venous circulation. (Figs. 132 and 133.) The forehead is covered with cold perspiration; the pulse is small, irregular, intermittent, and frequent; the cardiac impulse often cannot be felt, and the alæ of the nose become distended. Certain patients seem apparently to recover for a while, but gradual unconsciousness supervenes and they finally die. Rehn considers that this is due to diastolic hemorrhage, contrary to the primary hemorrhage, which is systolic. The heart action becomes so feeble, due to the first severe unconscious attack, that the wound ceases to gap and hemorrhage stops for the time. The possibility of recuperation is thereby offered until the increased action of the heart destroys this compensation. In other cases improvement may continue; the pulse becomes better, cyanosis is less, breathing is freer, and consciousness returns. These are cases in which the hemorrhage has ceased or in which the first violent symptoms were due to shock. If the threatening symptoms continue without intermission, or if convulsions occur with violent pain in the region of the heart, and should the cardiac activity become excited with extreme pallor and restlessness, there is probably continued internal hemorrhage into the pericardium and pleura to which the patient gradually succumbs.

Fig. 132.



Stab-wound of right ventricle: wound of entrance.

Fig. 133.



Stab-wound of right ventricle: wound of exit.

Some individuals do not experience any sensation whatever at the moment of injury, and may even walk a considerable distance. It has even happened that neither the patient nor the physician had any idea at first of the severity of the wound. Alarming symptoms may not develop for hours, or even days, and may then be followed by a fatal termination. There is no doubt that the size and position of the wound are of considerable importance, although there are cases in which the clinical signs did not correspond to the extent of the damage. G. Pisarzewsky treated a patient who complained at first of pain in the chest and continued to walk about. He died suddenly after seven hours, and on autopsy it was found that a revolver-ball had traversed the left ventricular wall. A finger could be entered into the canal. The ball had also passed through the upper left lobe of the lung and produced marked hæmothorax (three quarts).

Other symptoms which may be present, although not characteristic of injuries of the heart, are violent thirst, vomiting, emptying of the bowels, paralysis of the left half of the body due to thrombosis, and delirium. Prolonged vomiting has not infrequently led to laparotomy, because it was supposed that there had been some injury to the abdomen. One of the most common, although not constant, objective signs, is an increase in the area of cardiac dulness due to blood in the pericardium. Air in the pericardium has also been observed at times. In these cases the area of cardiac dulness may be entirely obliterated. The heart-sounds are sometimes quite clear, although they are frequently not heard at all or seem very distant. Splashing sounds are sometimes heard, the diagnostic significance of which has been emphasized by Reynier. He considers that this is proof of accumulation of air and blood in the pericardium. The author has been able to hear this sound at considerable distance in a patient who had been run over and sustained an injury to the heart. Blowing sounds, metallic ring, and purring noises, especially when the septum has been perforated, as in Brugnoli's case, have also been observed. Rose claims to have noted a metallic ring simultaneous with the heart action in almost all of his cases.

There are, of course, symptoms referable to the lung and pleura, which are injured at the same time in the majority of the cases. Great care should be exercised in judging of their importance, as emphasized by Fischer. Hæmothorax and pneumothorax and hæmoptysis are quite common. Loison observed complications with injuries to the pleura in 45.5 per cent. of his cases. The left side was involved 29 times, the right 7 times, and both 5 times. The lung was injured 12 times—*i. e.*, 15 per cent. It is uncommon to have the diaphragm, stomach, or liver injured at the same time.

The external wound shows nothing of especial interest and differs in no way from injuries of this sort to the chest in general. It depends entirely upon the sort of instrument that inflicted the wound. In some cases it gaped, in other cases it seemed to pulsate. There may be no hemorrhage whatever through the wound, and in other cases it may be profuse, and the blood is either dark or light according to whether the right or left ventricle has been injured. The hemorrhage may be due, however, to injury of the internal mammary artery or of the intercostal arteries, but these cases are comparatively rare.

Provided the wounded individual recovers from the immediate results of an injury to the heart, such as shock and hemorrhage, the secondary symptoms will have to be dealt with. Pericarditis must be considered first of all, for it may be very disastrous to the patient. This is correctly considered to be a very important and almost constant symptom of injuries of the heart, and frequently at a late date establishes the diagnosis that there was a primary injury of the pericardium or of the heart. The majority of the wounded are very weak for a considerable time. The pulse is irregular, and the patients are very excitable and apt to become dizzy. Whenever the exudate is of a septic nature, the danger is great indeed.

Even after a patient has withstood the primary and secondary symptoms there are several changes in the heart which may lead to death, and that are dependent on the primary wound. These are not common, and manifest themselves very late, but should be carefully watched for. There are apt to be universal pericardial adhesions, hypertrophy of the left ventricle, aneurismal distention of the right ventricle, or endocardial deposits of some sort. It is evident that the clinical picture may be very difficult to interpret, as shown by the cases of Mühlig, Kundrat, and others.

Although some slight injuries of the heart may produce alarming symptoms, other extensive injuries may be productive of but slight signs. Cases have been reported in which bullets remained in the heart as long as thirty years without producing special symptoms. Not infrequently small foreign bodies are found by accident in the heart that during life gave rise to few symptoms. Fischer collected 47 cases in which foreign bodies remained in the heart for a varying length of time. Many of these were in the pericardium, others in the muscle of the heart, and quite a number in one or the other cavity; either free or more or less encapsulated. Needles have been found in great number projecting into the lumen of the ventricle and giving rise to no symptoms whatever for years.

In a case reported by Finckh the right ventricle and the left auricle had been shot through by a revolver-bullet without causing effusion of blood into the pericardium. The patient died after sixteen hours, due to a gunshot-wound of the brain that occurred at the same time. Zemp reports a case in Krönlein's clinic in which a patient lived six days in spite of perforation of the right ventricle, the ventricular septum, and the injury of the left ventricle, without perforating the latter however. The aorta was also perforated. Death took place suddenly. The ball had been removed from beneath the skin on the fourth day just outside the vertebral column. In another case the pericardium, the right auricle, the atrium, and the lung had been perforated. This man died after forty-two hours, not as the result of the cardiac injury, but owing to an injury of the brain.

Diagnosis.—As is quite evident, there are no characteristic signs for the diagnosis of injury of the heart. In some cases this may be supposed to be present when none has been inflicted, and in other cases other symptoms may be so deceptive that no suspicion of the severity of the injury arises. Whenever there is extensive loss of substance in the thoracic wall, the diagnosis may be quite easy; but in stab-wounds, incised wounds, and gunshot-wounds, with small openings, the surgeon is only able to decide upon the nature of the injury from the presence of certain symptoms. In some cases digital exploration has enabled an accurate diagnosis.

The position of the wound, first of all, and the presence of blood in the pericardium, with a more or less extensive outline of dulness and displacement of the heart, are of primary importance. Superficial rapid breathing, up to 76 or more, the movement of the alæ of the nose, irregular heart action, marked sense of anxiety, restlessness, small irregular pulse, pain in the region of the heart, and cyanosis with a peculiar type of collapse, are of importance. In some cases the external wound may pulsate. Sometimes the heart-sounds may give information.

As already emphasized, the author considers the use of a probe for determining whether the heart is injured or not a very risky procedure. He believes one is liable to do more harm than good, and does not consider the danger of infection so great as the mechanical damage and its consequences.

Prognosis.—The prognosis of injury of the heart generally is not favorable. Formerly all injuries of the heart were considered positively fatal, but at the present time it is evident that even very severe injuries of the heart may recover.

Fischer calculated that about 10 per cent. of the injuries of the heart terminate favorably. Loison reported 9 recoveries of 23 needle-wounds, 11 after 90 stab-wounds, but only 3 of 110 gunshot-wounds. Jamain reports 16 recoveries of 121 cases. Rupture of the heart and rupture of the valves of the heart are very unfavorable.

Aside from the kind of injury and its extent, the region of the heart injured must be taken into consideration. Injuries of the apex offer the best chances for recovery. Next are the right ventricle and auricle, and then the left side of the heart. The prognosis is unfavorable when the coronary vessels have been injured, for most of these patients die quickly, which is in accord with the experiments made by Bode and Wehr. However, cases of recovery are reported. The direction of the wound has a certain amount of influence because the more slanting its course, the greater the probability of its closing.

It is, of course, of vital importance whether the wound has become infected or not, for the fate of the individual after the first danger is passed depends largely upon this factor. Many patients die as the result of secondary infection.

Conner's (Cincinnati) case is unique. The bullet passed through the right and opened the left ventricle, and passed out of the left auricle, and became encapsulated in the lower lobe of the right lung. This patient died after thirty-eight months. There had been profuse bleeding, pneumonia, pericarditis, and endocarditis. Brugnoli reports a similar case. A shoemaker was stabbed in the heart and died after nineteen years and seven months. There was a scar in the right ventricle about 3 cm. long and one in the ventricular septum and mitral valve. In a case reported by Dent death took place one and a half weeks after a penetrating gunshot-wound of the heart; and Küttner is of the opinion that recovery is not impossible with wounds inflicted from a considerable distance.

It is well known that when the damage to the heart is not very extensive the wound becomes closed rather rapidly with fibrin, which is later changed to connective tissue. There is no regenerative process of the heart muscle. In rare cases the scar may be slightly bulging, although the original closure with fibrin is pretty firm. A thrombus may occlude the inner opening of the wound, as in Delmas' case. This patient died fourteen days later of hemorrhage from the lung. In the left ventricle a thrombus was found which plugged the wound completely. Hemorrhage from small wounds is probably checked by the action of the powerful ventricular muscles themselves. They simply close the opening as in other muscular organs.

Death from wounds of the heart is due chiefly to the hemorrhage, or to the pressure of the blood poured out into the pericardium. Knoll found that pressure which rapidly became greater than the atmospheric pressure first increased the arterial pressure slightly and then caused the latter to diminish. It is not possible, however, to stop the heart action by forcing air into the pericardium, although the blood-pressure may be lowered. Simple pressure of the hand is able to do this. The veins become overdistended. When the air escapes rapidly from the pericardium, the blood-pressure sinks rapidly and then rises sharply, exceeding the original pressure. Circulatory disturbances in the brain and changes in the respiration are also observed.

The results of pericardial effusion are evident. The veins become distended and the arteries contain less blood. There are reflex diminution of the vagal impulse, increased pulse-rate, and cerebral disturbances.

Concerning cessation of the heart action with relatively slight injuries, Rehn has shown that this cannot be due to injury of the cardiac ganglia, as automatic centres of motion, because they are sensitive organs derived from the sympathetic system. The heart itself is the automatic and regulating motor. Some reflex action is probably concerned which is perhaps less frequently disturbed than might be supposed, although this is very possible, judging from the author's observation upon concussion of the chest. The fact that the heart action may cease for a few moments following a stab-wound of the muscle is in favor of this view. It cannot be claimed as yet that certain regions of the heart are more or less vulnerable, but it seems probable to the author that the ganglia react more to an injury. The ventricles, however, have no ganglia. The most sensitive regions are in the vicinity of the auricle. Kronecker assumes that there is a nervous centre in the septum. Direct or reflex stimulation of this may constrict the coronary arteries. He observed that a stab in the upper third of the septum stopped the action of a dog's heart. The heart flickers out. There are disturbances of co-ordination in the action of the muscle which is so irregular that it is unable to force the blood out of the ventricle. Acute anæmia of the heart-wall paralyzes the function of the cardiac nervous system. Certain peculiarities connected with injuries to the heart are made more intelligible in this way.

Bode found that hemorrhage from the right ventricle was greater than that from the left. Diagonal wounds close easier than others. Hemorrhage may be stopped by the formation of clots, especially in the left ventricle. He furthermore demonstrated that injuries of the coronary arteries are followed by cessation of the heart action very quickly, and injuries of the auricles are more dangerous than those of the ventricles. Perforation of the right ventricle is more serious than that of the left. Death may also be produced by aspiration of air. Elsberg's experiments corroborate Bode's statement, and prove that the heart is very tolerant to certain kinds of interference. In small stab-wounds, even small incised wounds 2 mm. broad, the left ventricle closes almost immediately. When the right ventricle is injured, however, the subjects bleed to death, as is the case with wounds of the auricles. Disturbances of rhythm occurred when the pericardium or the endocardium was divided. The heart muscle itself seems to be very tolerant. The animals recovered from complete division of the lower section of the heart or from partial resection of the ventricle with subsequent suture. A temporary ligature was placed around the heart above the region incised, which, strange to say, the animals seemed to stand extremely well.

Wehr's experiments prove that a section of the ventricle may be removed in animals, although he lost all of the animals from cessation of the heart action where he made use of elastic pressure for the purpose of arresting the bleeding while operating.

Treatment.—The treatment of injuries of the heart is first of all symptomatic. Rehn has proved that wounds of the heart may be sutured with success under certain conditions. Many other authors have demonstrated the success of suturing the heart, some of whom did not lose their patients for several days after operation. The fatal result in the majority of cases was due to other causes. The left ventricle has been sutured without anæsthesia. Spencer was able by packing to arrest the hemorrhage from a wound of the heart. Secondary hemorrhage occurred repeatedly, although recovery took place after six weeks. This patient died three months later from some unknown reason, probably as the result of anæmia. The autopsy showed the wound in the heart to be completely healed. Walker reports 3 cases of stab-wounds that recovered without suture.

The deep unconsciousness which is associated with injuries of the heart is not infrequently the best aid to treatment. The very weak contraction of the heart and the slowing of the blood-current allow the wound in the ventricle to become plugged. After treating the external wound absolute rest is indicated, and everything which could alter the heart action ever so little should be avoided. If transportation is necessary, this should be done with the utmost precaution. This rest, which should be combined with extreme precaution in feeding, should be carried out for fourteen days at least. Cold milk is the best diet. Morphine should be given subcutaneously if the patients are restless, especially if the respiration is rapid, even though considerable anæmia may be present. Ice-bags should be used over the heart. Digitalis may be of value. Autotransfusion or infusion with normal salt solution may be necessary if there is danger of collapse. Certain cases are doubtless saved by these measures. The patient becomes quieter, the pulse improves and becomes regular, and respiration is freer.

It appears to the author questionable whether the instrument that inflicted the wound should be left undisturbed until ready for sewing the heart, as recommended by Rydygier. It cannot be determined beforehand whether the heart has been injured or not, and whether the instrument really packs the wound, as it were. Needles that can be grasped should be immediately removed, even if one has to enlarge the external opening. The author has already emphasized that in cases of injury of the internal mammary artery the vessel may be packed if necessary.

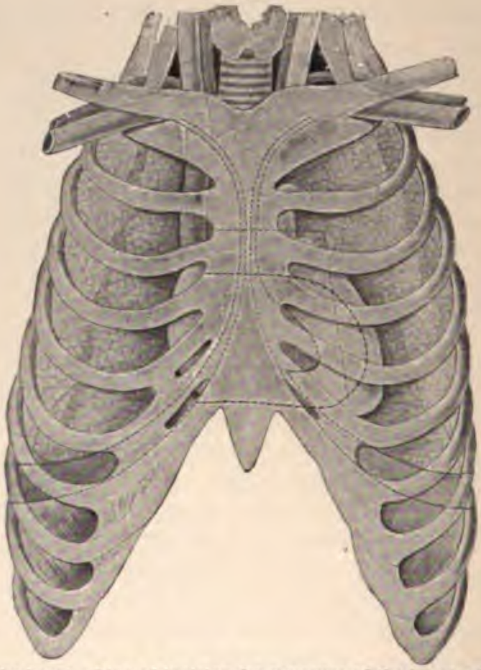
Formerly bleeding was used extensively for the purpose of regulating the heart action, although this has of late been almost completely discarded. In one of Rose's cases, in which there was a gunshot-wound of the pericardium and of the septum without perforation, the hemorrhage ceased after energetic venesection. In another patient with considerable pressure around the heart following a dagger-wound the pulse improved and dyspnœa disappeared after this form of treatment. The general condition of the patient should be taken into consideration. Many patients have already lost a considerable amount of blood, so that the quantity they have is essential to them. The author does not wish to advocate venesection as a matter of principle in all cases, for in the majority there will be no indication whatever. Besides this, the surgeon should remember that it is by no means a matter of indifference whether the right or the left ventricle has been injured. In the former case there is already considerable venous hemorrhage.

The pressure brought to bear upon the heart by the blood accumulating in the pericardium is of great importance, as emphasized by Morgagni and later by Rose. Surgeons are familiar with the damage that may be done by accumulations of fluid in the pericardium from observations in processes associated with exudation. These, however, develop slowly, and the heart muscle has time to accommodate itself. This is not the case when a large quantity of blood is suddenly poured out into the cavity. Rose recommends puncture or an incision. Considering the knowledge regarding the position of the heart and blood in the pericardium, the author prefers incision by all means, and makes use of the external wound if in any way possible.

For the purpose of exposing the pericardium, it is best to make an incision in the fourth or perhaps in the sixth left intercostal space close to the sternum. The cartilage of the fifth rib may be resected because it is then possible to expose the heart for the purpose of suturing if necessary. Rehn divides the rib in the mammary line and turns it back at the joint with the sternum. If necessary, the fourth rib may also be resected. There is no doubt that that portion of the heart that is most frequently injured is exposed in this way—*i. e.,* the anterior wall of the right and left ventricles. In Rehn's case there was a stab-wound in the right ventricle about 1.5 cm. long. It is not likely that it will ever be possible to suture the auricles.

Suture of the heart, although freely exposed, is not easy. Rehn emphasizes that the heart may be made more accessible by traction on the pericardium. The left half of the heart should be sewn in systole and the right in diastole. The first stitch is the most difficult to place. The subsequent stitches are easier because the right one may be used as a guide. The tendency to rotate on itself is very disturbing, as is also the change of position that takes place, because the heart tends to disappear partly under the sternum. A thread passed through the apex is the best means of controlling the heart, as the author has found in experiments on animals. It may be of considerable aid to press the heart up against the chest-wall. Catgut or silk may be used for sewing. Sometimes the stitches tear out immediately on account of the friable consistency of the heart muscle. It should not be forgotten that the manner of exposing the heart may render the operation of sewing considerably easier. The conditions, however, may force the surgeon to desist from more extensive interference and satisfy himself with resection of the fourth and fifth ribs only. This will as a rule expose the greater portion of the heart. In some cases in which there was supposed to be injury of the heart itself the operation showed that there was only involvement of the pericardium. In this case resection of two ribs is sufficient. Cappelen resected the third and fourth ribs;

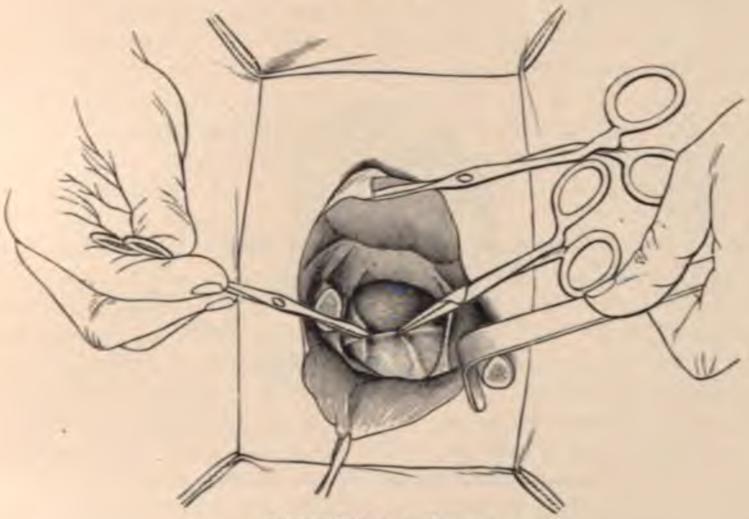
FIG. 134.



Topography of the heart. Line of incision for exposure of the heart, after Rydygier and Wehr. (Jössel, Waldeyer.)

Stelzner and Rehn resected the fifth; and Pamoni resected the third rib from the sternum to the mammary line and made two vertical incisions at the end of the first cut downward to the fifth intercostal space; he then resected the fourth and fifth ribs. This rectangular flap was then turned downward. Parrozzani makes a triangular flap, including the sixth, seventh, and eighth ribs; and Podrez makes a similar flap, including the cartilage of the sixth, seventh, and eight ribs with the left half of the lower portion of the sternum. Giordano and Del Vecchiomake an H-shaped incision including the third and fourth ribs. Rydygier makes a horizontal incision immediately above the third pair of ribs, extending farther to the left of the sternal margin than to the right. The second incision is carried diagonally downward and outward across the third, fourth, and fifth ribs close to their bony ends. The periosteum is lifted off of the sternum at the transverse incision and the bone divided. The three cartilages are divided in the line of incision. This triangular flap is carefully dissected up, keeping close to the posterior surface of the bones. It is then reflected to the right, which does not seem especially easy to the author, because the sternum has been divided in only one place. The pleura and pericardium are left intact as well as the internal mammary artery. Wehr recommends a horseshoe-shaped incision that divides the sternum in two places as well as the cartilage of the fourth, fifth, and sixth ribs. This flap, including skin, muscles, cartilage, and bone, is reflected to the right. The incision commences at the right margin of the sternum in the third intercostal space, and is carried to the left downward and outward and then back across the sternum over the ensiform process.

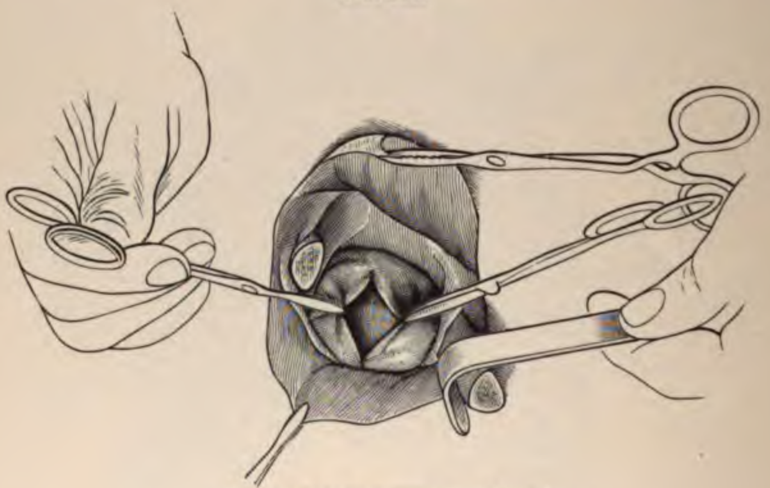
FIG. 135.



Pericardiotomy. (Lejars.)

The sternum is divided subperiosteally twice, the cartilages cut in the line of incision, and the whole flap carefully dissected up. Both of these operations have not been tried on living subjects. Watten reaches the right ventricle in a case of stab-wound in the fourth right intercostal space 2 cm. from the margin of the sternum by resecting the fourth costal cartilage and making a flap of skin, muscle, and bone along the margin of the sternum up to the second rib. This operation was successful and the wound sutured. E. Rotter and Ninni recommend a door-like incision, beginning 1.5 cm. from the left sternal margin and following along the lower margin of the third rib for about 10 cm. The second incision is made along the lower margin of the fifth rib, and the ends of the two incisions joined. The ribs are divided and the soft parts and bone turned back toward the sternum.

FIG. 136.



Incision of the pericardium. (Lejars.)

After drawing the lung to one side the pericardium is opened diagonally downward and outward. No attention is paid to the pleura, because it is usually already injured. Marion also recommends an incision similar to the above, although he includes the left portion of the sternum. This method is much more drastic and does not prove of especial advantage. According to the author's opinion, if simple resection of the rib is not sufficient, Pamoni's method will prove efficient. In many cases it will be necessary to operate as rapidly as possible to obtain a favorable termination.

The next question is, Which cases are to be sutured, and when is this to be done? Most patients bleed to death before interference is possible; therefore the majority of operative cases are small stab-wounds in favorable regions of the heart. Some regions of the heart are inaccessible if injured. Wounds of the anterior surface of the right or of the left ventricle are most favorable for suture. When the injury is situated pretty far back, the chances are less favorable. Fortunately most injuries are found in the anterior region. If the posterior wall is perforated, operative interference can hardly be considered. The immediate steps, of course, cannot be decided beforehand. If the wounded individual has survived the first dangers, and if the clinical signs suggest continued hemorrhage, as indicated by increasing anæmia, increase in the area of cardiac dulness, small pulse, rapid and labored breathing, operative interference will be indicated. The pericardium should first be exposed. The subsequent steps will depend on the conditions present in the individual case. It should be again emphasized that some cases recover without operative interference even when there are alarming symptoms. The coronary arteries have been ligated repeatedly, sometimes with temporary success (Cappelen), and sometimes with permanent results (Tassi).

It was mentioned in connection with injury of the pericardium that pericarditis and empyema of the pericardium may necessitate pericardiotomy. Simple puncture is not sufficient. Other complications, such as empyema of the pleura, may make the prospects of recovery from an injury of the heart unfavorable. Rehn was obliged to perform thoracotomy in one of his patients.

As regards after-treatment, absolute rest and great care are necessary for a long time, because rupture of the fresh scar-tissue with a fatal result may take place after many weeks, as proved by Krawkoff's observations.

Injuries of the Large Intrathoracic Vessels.—Injury of these vessels is rarely the subject of medical interference. The majority of individuals suffering from injuries of this sort die immediately from hemorrhage; few survive for any length of time. Sometimes there may be only a tiny opening that closes of its own accord, or the vessel is only grazed, so as to form an aneurism which delays the fatal moment for a varying length of time. Gluck observed an aneurism of the descending aorta 4 cm. above the aortic opening in the diaphragm following a gunshot-wound. The case died seven weeks after the injury. In the American Civil War 2 cases of injury of the innominate artery were reported that caused death after considerable time. In 1 case an aneurism developed.

It has occurred that the ball occluded the opening in the vessel for some time. The vessel-wall was probably not completely torn through at first, but rupture was made complete by pulsation. Cavasse reports a case in which an individual was stabbed through the pulmonary artery and lived eleven hours; and Billroth saw a patient survive a stab-wound of the innominate vein for three days. Zemp's patient, whose aorta had been shot through, died on the sixth day. The right ventricle and the septum had been perforated at the same time. Pelletan and Levrouge report cases in which death followed puncture of the aorta eleven days and two months after the injury. Heil reports a stab-wound of the aorta which recovered. The injury was probably slight. Perthes reports a case in which two aneurisms developed following injury of the pulmonary artery and aorta after a gunshot-wound. This patient died ten months afterward from pneumonia. The day preceding his death he had been operated, on for empyema that had existed before he was injured. Perthes was able to collect only 12 cases of injury of the aorta that were not immediately fatal. Hankel has recently reported a case of stab-wound of this vessel which lived for fifty-seven days. An aneurism developed which caused death by pressing upon the trachea.

The large vessels of the chest may be injured from within by splinters of bone, needles, fish-bones, etc., reaching them from the œsophagus. The innominate artery has been tied repeatedly. Smith had one successful result, and several patients operated upon have lived sufficiently long to lead one to suspect that other causes than the direct results of the operation led to a fatal termination. The technic of this operation has been rendered considerably easier by resection of the manubrium, a portion of the clavicle, and the cartilage of the first and second ribs, as recommended by Bardenheuer.

Injuries of the Thoracic Duct.—Injuries of this structure do not as a rule cause severe symptoms. Usually there are other injuries which complicate the clinical picture. Small wounds may close spontaneously on account of the power of contraction which has been observed by various authors in executed individuals. The pressure in the duct is very slight, which favors this end. The cases of injury reported in literature must be considered with some precaution. The symptoms of pressure are probably due to effusions in the pleura or to hæmothorax, and an absolute diagnosis is impossible. In one case reported there was tuberculosis of the pleura. The treatment is symptomatic entirely. Boegehold investigated the effect of tearing the duct in animals, and came to the conclusion that some died of inanition and pressure on the lungs and heart due to extravasated chyle.

Injuries of the Diaphragm.—Injuries of this structure are quite frequent, and are either compound or simple. The former are the result as a rule of gunshot-wounds or stabs, which always open the peritoneal and pleural cavities. They usually divide the diaphragm diagonally from below upward or the reverse. Force applied to the body at right angles to the surface may rupture the diaphragm on account of the dome-like shape of this membrane. As a rule the viscera of the abdomen and chest are injured at the same time. The lung, liver, stomach, and intestines are frequently involved. It is evident that these complications increase the danger of laceration of the diaphragm, which in itself is not very severe, so that the prognosis is doubtful. Nobiling's case proves how many complications may be present. In his case the stomach, lungs, and pericardium, as well as the diaphragm, were injured at the same time. A portion of the stomach and loops of intestine not infrequently enter the pleural cavity through the opening in the diaphragm, giving rise later to severe symptoms. In many cases the injured individuals die as the result of these incarcerated hernias. Spilmann reports a case in which a piece of omentum which protruded through a stab-wound into the left side of the chest was removed. The patient died on the eleventh day from incarceration of the stomach, which had taken place through a very small opening in the diaphragm. Schoezler reports 2 cases of stab-wounds of the diaphragm that died after six months and one year, respectively, from strangulation. Bardenheuer operated upon a man for occlusion of the bowel seven and a half years after he had been injured, and was unable to reduce the incarceration. The autopsy showed a small opening in the diaphragm through which a piece of the omentum and intestine had passed. This patient had often suffered from abdominal pain, constipation, and dyspnœa since his injury, which had healed within four weeks. Llobet operated upon a case one year after injury and resected ribs with good result. Farinato performed the same operation ten months after the accident through the pleural cavity, as recommended by Postempsky-Rydygier. The large intestine had entered the pleural cavity and caused signs of strangulation comparatively early.

Gunshot-wounds of the diaphragm are usually complicated, although remarkable cases of recovery have been reported. Just as in contusion of the chest, there are simple subcutaneous ruptures of the diaphragm that produce so-called diaphragmatic hernia, which are really only a sort of prolapse, because they do not have any sac as a rule. Lacher collected 276 cases, 28 of which had a sac, but found only 3 of the acquired variety. The opening in the diaphragm is frequently so large that a considerable portion of the abdominal viscera may enter the chest cavity. The author has found the stomach, a portion of the colon, and part of the liver dislocated without the patient being in the least disturbed; later he died from an intercurrent disease. Many of these cases have been reported in literature. The spleen has also been found dislocated. When the gap in the diaphragm is small, symptoms of strangulation may develop soon after the injury, and have not infrequently been followed by a fatal termination. The muscle-fibres may rupture longitudinally or transversely. The direction probably bears some relation to the tendency to constrict the hernia.

Weiss observed an accumulation of bile in the chest after rupture of the diaphragm and liver. This case was cured by aspiration.

It is rare to find thoracic viscera displaced into the peritoneal cavity after rupture of the diaphragm. It need not be especially emphasized that death may take place within a short time if the stomach or intestine have been ruptured at the time of injury. Rupture of the diaphragm has been observed as the result of severe contusion. Even the act of vomiting or the strain during labor has been responsible for this accident.

Symptoms.—The symptoms vary according to the complications present. There is no typical picture of rupture of the diaphragm. Generally speaking, one assumes that the patient will have marked pains in the region of the membrane, which will be increased and radiate toward the shoulder if he is moved, and especially during forced respiration or on coughing. Diaphragmatic respiration is reduced to a minimum. Sometimes marked dyspnœa has been observed, especially if certain of the abdominal viscera have entered the thorax and compressed the lung considerable. The heart may be displaced, leading to more or less pronounced circulatory disturbances. Compression of the heart may also cause difficulty in breathing. These symptoms usually follow the injury immediately, although they may develop after some time, so that there may be doubt whether they really bear any relation to the accident. Sometimes they are produced by secondary strangulation.

Disturbances of the digestive tract are frequently noted. These may be simple or extremely dangerous, and indicate the trouble by the appearance of symptoms of intestinal obstruction and strangulation. If they persist, death may follow. Whenever a considerable portion of the abdominal viscera have entered the thoracic cavity, the abdomen may appear depressed and the corresponding side of the chest will bulge. Percussion will show characteristic signs. When the stomach or intestine is dislocated, there will be a peculiar tympanitic note to the chest, which may lead one to suspect pneumothorax. Auscultation will show the absence of respiratory murmur except at the apex of the lung. If fluids are introduced, a splashing sound will be noticed. If a Seidlitz powder is given so that the stomach is distended, the note will be changed immediately. On tapping the patient, distinct splashing sounds may be elicited. Aside from these signs, secondary conditions, such as pleuritis and peritonitis, may produce severe symptoms, and at times be followed by death within a short time, which is not infrequently the case with compound injuries.

A symptom which is claimed by some to be especially characteristic is the so-called "sardonic grin," which, according to Boyer, is still observed on the face of corpses that had received at the time of death some sudden injury of the diaphragm.

Diagnosis.—The diagnosis is not easy, and may be impossible in view of the fact that many cases do not present marked symptoms. Characteristic symptoms develop only after certain of the abdominal viscera have become displaced into the thoracic cavity. Depression of the abdomen, bulging of the thorax, tympanitic note, a sound as of dropping water in the interior, a sense of fulness, eructation of gas, nausea, and dyspnœa are the chief signs. If symptoms of strangulation are added to these, then the diagnosis will be more definite. If the stomach is dislocated, information may be obtained by administering a Seidlitz powder.

Prognosis.—The prognosis depends upon the complications present. Wounds of the diaphragm itself are not of grave significance, as shown by many observations. The former view that these injuries were absolutely and immediately fatal has long been abandoned, although many of the wounded died immediately. The cause of death was probably some complication. The prognosis is always doubtful, because all sorts of accidents may happen later. When there is considerable constriction, the entire dislocated portion of the intestine may become gangrenous, as shown by Dollinger's patient, who died four months after receiving an injury. Some of the cases died because more and more intestine entered through the opening, or because the local conditions became changed on account of some complication, such as pregnancy. As far as the process of repair of wounds of the diaphragm is concerned, there is no doubt that cicatrization may take place, although it is quite certain that most of the injuries do not close, chiefly on account of the hernia.

Treatment.—The treatment in many cases is hopeless. This is especially the case with complicated wounds. Whenever the surgeon has become convinced that there is some internal strangulation, he should not hesitate to perform laparotomy. The results up to the present date are not especially encouraging. In the case reported by Galassi and Ferreri, the constricted portion of the intestine could not be found; but Seydel and others have had favorable results after suture of the diaphragm. Simple reduction of the hernia is not sufficient because it may reappear at any moment. In recent cases the diaphragm should be sutured immediately. Even where there is considerable loss of substance the wound may be closed by proper placing of stitches, as proved by v. Noorden's and v. Mikulicz's cases. Schlatter advises against laparotomy, provided the injury is seen through the pleural cavity and can be sutured from this side. In old injuries it will be necessary to freshen the edges before sewing. In cases in which the intestinal contents have been poured out into the chest cavity and pleuritis has developed, the chest should be opened as soon as possible and washed out. Postempsky's procedure of temporarily resecting the ribs is to be recommended. Ricolfi has had good results with this operation.

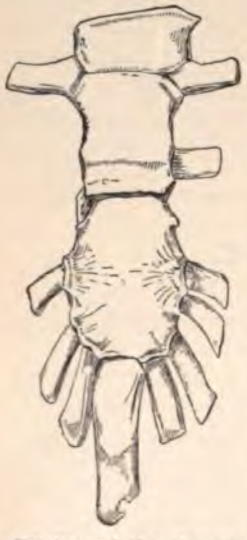
FRACTURES OF THE STERNUM.

Fractures of the sternum are not common. Gurlt and P. v. Bruns' statistics show a percentage of about 0.1 to 0.09 of all fractures. The younger the individual, the rarer the fracture, and cases under twenty years of age are extremely rare. The elasticity of the chest, as has been explained, especially in youthful individuals, in whom the cartilage has not undergone any change whatsoever, is great. Fracture of the sternum is produced as a rule by some violent force acting suddenly. Simple fracture of the sternum is rare for this reason, and in a majority of the cases these fractures are combined with other severe injuries, compared with which the damage to the sternum is insignificant. There is only one exception to this rule, as will be seen later. Usually some direct form of violence produces a solution of continuity, such as a sharp blow, a horse-kick, a fall, or a general shaking up. Sometimes "getting run over," getting caught between cars, or some similar injury, is the primary cause, although a very slight force has been sufficient.

Besides direct force, there are other methods of producing a fracture of the sternum, such as traction, for instance. A considerable number of cases have been reported due to this variety of force. It was formerly presumed that these fractures were due to contrecoup. In most cases, however, the vertebral column has been overextended and there has been marked tension put upon the central and peripheral portion of the muscles inserted into this region of the sternum, which by acting in opposite directions tear the bone in two. Most cases combined with fracture of the vertebral column are due to this kind of injury. Many of the patients have fallen upon the back and landed upon a stone or a beam. After fracture of the column traction upon the sternum is in no way interfered with, and separation may take place immediately. In a case of the author's the patient fell onto a pile of stones. Simple accidents, however, the mechanism of which is perfectly evident, may be sufficient to produce this lesion. There are a number of observations in which this lesion has been secondary to extreme bending back of the vertebral column.

Faget reports the case of a man who, endeavoring to bend over backward and lift a weight with his teeth, fractured his sternum. Pluskal reports a patient whose sternum was broken by a quack in an endeavor to remove pain in the lumbar region by bending him backward. Féré reports the case of a man who fell backward across a beam and touched the ground with his head; the sternum snapped at about the level of the third costal cartilage.

FIG. 137.



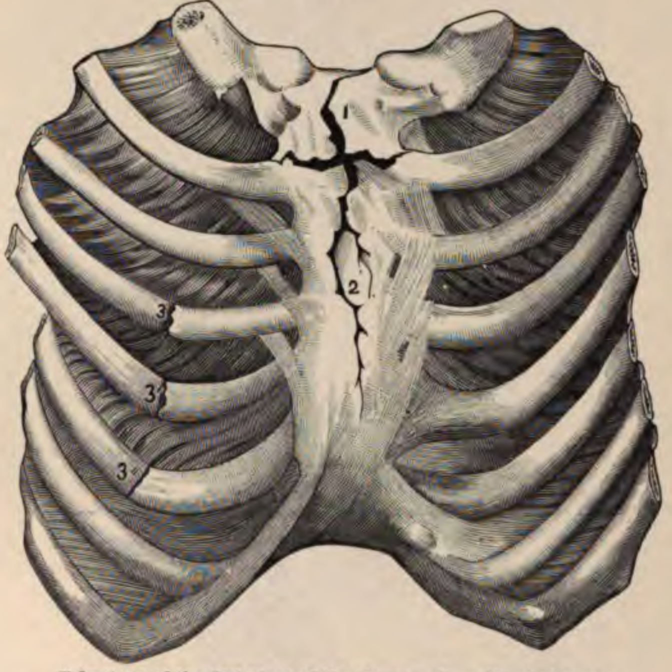
Fracture of the sternum through the middle of the body: deformed ensiform cartilage.

Many cases of fracture have been reported during delivery, while coughing and sneezing, and while lifting heavy weights or while hanging by one hand. Boyer expressed the opinion that the sternum appears to snap like a string fastened at both ends. It is evident that in the latter cases the fracture is due to muscular action. This view is further supported by the fact that the posterior lining of the sternum is not torn, but simply bruised. All the fractures are transverse. Hytl is of the opinion that these fractures do not take place while bending backward, but in the endeavor to straighten the body. This is not the case in the majority of injuries, although it seems to apply to the patient reported by F. Beverly-Bogg.

A further variety of fracture of the sternum is produced by falling forward. The mechanism of these fractures has been explained in various ways without any uniformity of opinion reached. There are cases in which it seems as if the lower jaw had depressed the manubrium, as is Diday's opinion, although in the majority of cases the sternum was probably kinked by bending the body forward sharply.

Fracture of the sternum may take place at any position. The most frequent seat of fracture is at the line of junction between the manubrium and body of the sternum, rarely between the body and the ensiform process. Diagonal fractures are uncommon, and longitudinal fractures are extremely rare, very few cases having been reported, the exact nature of which is not certain. Double fractures of the sternum are rare. Kreis has reported a case of this sort in which the middle section was displaced, so that the proximal and distal portions were behind it. In the majority of cases the fracture was complete. Only 2 cases of incomplete fracture have been reported. Stellate fractures are also uncommon. Several fractures with loss of substance have been observed, and will be more common with the use of modern projectiles.

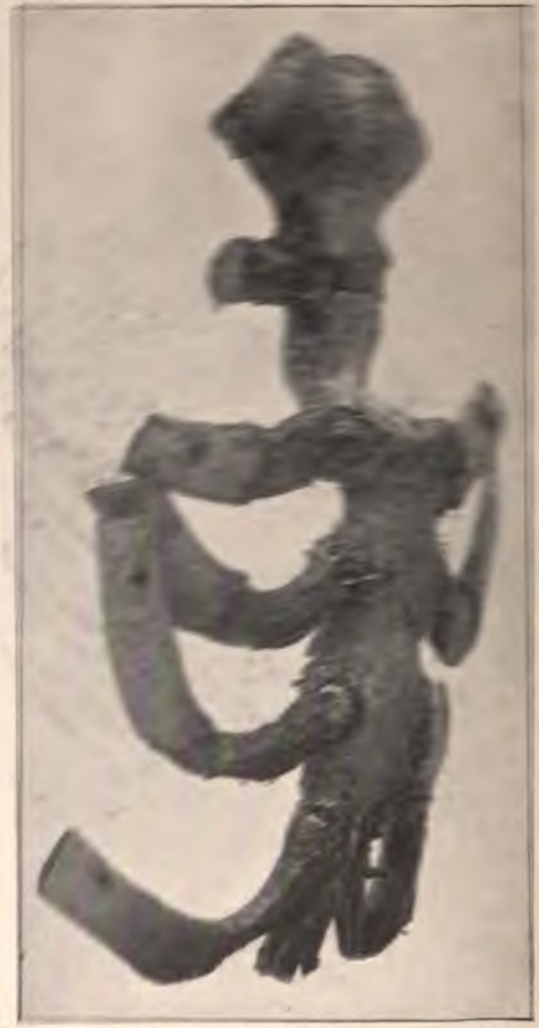
FIG. 138.



T-fracture of the first piece of the sternum from direct violence.

The solution of continuity between the manubrium and the body of the sternum has been called luxation by some authors. This would be justifiable if there were a true joint between the pieces. Various views are entertained on this point. German authors consider this union to be a synchondrosis, consisting of three layers : a central and peripheral, a hyaline, and an intermediate fibrous layer without any sharp line of demarcation. French and English authors claim that a joint is frequently found. Maisonneuve declared the union to be between an amphiarthrosis and a diarthrosis. Rauge claims that there is a joint in the majority of cases. Brinton and

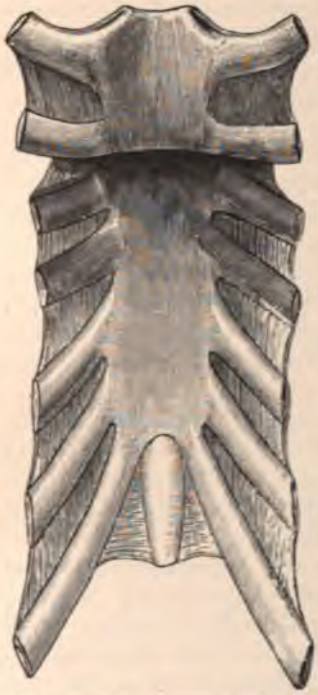
Fig. 128.



Displacement of fragments in fracture of the sternum. (Dennis.)

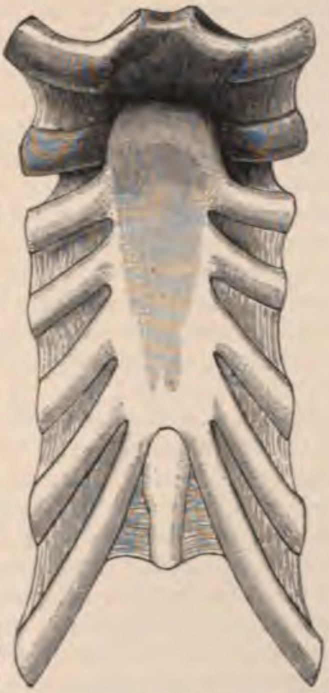
Rivington hold similar views. The author's investigation leads him to believe that in most cases there is a synchondrosis, and that three different layers can be distinguished microscopically and macroscopically. There is a central slit only in exceptional cases. In one case the joint of the second pair of ribs was continued inward almost to the median line, where a cartilaginous septum separated them. Bony union was not infrequent at all ages. Luschka claims that the joint is more frequent in older than in younger individuals, and that it always develops after birth. Sometimes the line of union is slanting. It will be seen that it does not accord with the conditions present to call the solution of continuity between the manubrium and the body of the sternum a luxation, and that it is more appropriate, as suggested by Gurlt, to assume the presence of a fracture. This view is supported by experiments. When the sternum has been separated, either the entire synchondrosis or a portion of this remains attached to the manubrium or to the body. It does not separate at the middle of the line of union.

Fig. 140.



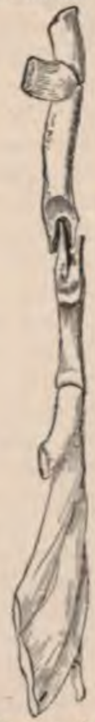
Fracture of the sternum with dislocation of the peripheral fragment on the anterior surface of the sternum. Anterior view.

Fig. 141.



Posterior view of Fig. 140.

Fig. 142.



Fracture through the middle of the sternum.

Clinically there is no way of differentiating. Brinton's view, that in luxation the ribs remain attached to the manubrium, is not tenable. Luxation could take place only by having the body displaced forward. The same applies to the ensiform cartilage.

Symptoms.—The symptoms vary according to whether there is simple fracture of the sternum or whether there are complications.

Cases occur in which the signs are at first so slight that the diagnosis has not been made. In the majority of cases, however, especially if the fragments are displaced, the symptoms will be sufficiently definite. Pain on pressure or on the slightest motion while breathing, crepitus if the fragments can be moved, and extravasation of blood will usually be found. Whenever there is displacement, the distal fragment with few exceptions will ride upward and forward on the proximal fragment. (Figs. 140 and 141.) The deformity is so characteristic that an error is hardly possible. The prominence of the displaced fragment is so great that it seems as if the manubrium were pressed backward. Compound fractures are uncommon. Duverney reports a case in which there was laceration of the skin over the seat of fracture.

The subjective symptoms may be severe, especially the interference with breathing. Most patients bend forward because in this position the muscles which are attached to the fragments are relaxed and the pain is less. They prefer a half-sitting position to a horizontal one.

The symptoms are, of course, more marked when there are complicating elements. As has been mentioned, there may be fracture of the ribs or of the vertebral column, or injuries to the thoracic or abdominal viscera which produce symptoms so marked that those due to an injury of the sternum itself are insignificant. Hæmoptysis and emphysema are not uncommon. Hæmothorax with alarming aftereffects may be secondary to rupture of the lung. Injury of the heart, the large vessels, the liver and other important organs, is usually followed by immediate death. A fatal result may be due to concussion of the chest.

As regards fracture between the ensiform and the body of the sternum, it may be mentioned that this is frequently associated with persistent vomiting, which ceases as soon as the fracture has been reduced. This injury is not uncommon during pregnancy. The fragment may be displaced backward or forward.

Diagnosis.—The diagnosis of fractures of the sternum will be evident from what has already been said, and is usually not difficult. Localized pain and displacement, even in the absence of crepitus, point to a probable fracture of the sternum. If the characteristic displacement of the fragments is present, there can be no doubt. It may be mentioned that a congenital longitudinal fissure of the sternum has been mistaken for fracture. Fracture of the ensiform cartilage is characterized by abnormal mobility, marked pain, and frequently by persistent vomiting.

Course.—The course of the injury does not depend so much upon the fracture of the sternum itself as upon complications. Simple fracture heals within a short time. The author knows of a case that healed in sixteen days in spite of hæmoptysis and pneumonia of the right side of the chest. The average duration of convalescence is four weeks. The callus is formed chiefly from the periosteum, and is as a rule not abundant. In a few cases a pseudarthrosis has been observed to develop. In compound fractures there is the danger of suppuration in the mediastinum in addition to infection of the wound. Suppuration has been known to take place even in simple fractures. The skin overlying the seat of fracture may become gangrenous on account of the tension placed upon it.

Prognosis.—The prognosis in simple fractures without dislocation is favorable. The process of repair is simple. Many cases show later a small transverse ridge of callus. When there is considerable dislocation, the chief question arising is whether this can be reduced or not. It will be seen later that this is not always easy. According to Gurlt, 9 of 44 uncomplicated cases died, whereas 45 of 61 compound cases succumbed. Even simple fractures may result fatally from secondary conditions. Suppuration may take place, which is dangerous on account of the possibility of involving the mediastinum. Fortunately the posterior lining of the sternum guards against perforation into this region as a rule.

Treatment.—The treatment of fractures of the sternum will depend upon the complications present, whether there is dislocation of the fragments or not. If there is no dislocation, and should there be no other complicating injury, simple rest in bed in a horizontal position, cold compresses, and morphine provided there is a tendency to cough, will be all that is necessary. Sometimes it is advisable to place a pillow beneath the back.

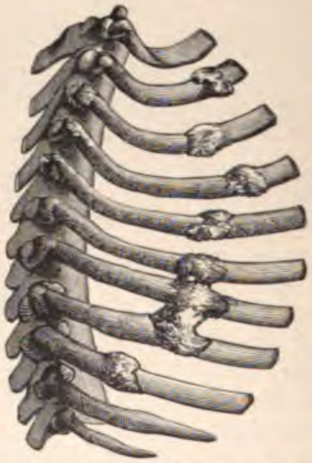
The reduction of any dislocation is a much more serious matter. It has always been presumed that this could only be done by traction upon the fragments, and consequently it has been the custom to overextend the vertebral column. This is best done by placing the patient on his back upon a double-inclined plane, which may be improvised, if needs be, by the use of pillows. It is best not to force the reduction, but to do this gradually. Demarquay reduced a fracture on the third day with permanent success. Duverney recommends the side position. Dupuytren's case shows that replacement may be a life-saving operation. A patient of his that had almost completely collapsed recovered after the dislocation had been reduced. When replacement is impossible in this way, and the symptoms indicate that the dislocation must be reduced, it may be necessary to resort to an open incision. The most rational method consists in exposing the prominent fragments by a longitudinal incision, and after separating the periosteum from the margin reduce with a chisel or bone-forceps. Care should be taken not to injure the posterior lining membrane of the sternum, nor the reflected margin of the pleura. Sometimes two lateral incisions may be necessary at right angles to the longitudinal one.

In compound fractures it may be advisable to clean the wound thoroughly and apply an antiseptic dressing. This should be done especially if the wound is several hours old, or when there is a possibility that it may have become infected. Splinters of bone should be removed. If suppuration occur, free drainage should be established. If the mediastinum has been opened, the prognosis is much graver. It is best to reach for the seat of fracture in these cases and drain the pus through an opening in this region. If one or the other of the internal mammary arteries have been injured, there may be considerable hemororhage and signs of pressure. As a rule the pressure is produced by the dislocated fragments, and a considerable quantity of blood, provided it has not become infected, will soon be absorbed. Hæmothorax and aspiration may be necessary in some cases. This is effective at times, although in other cases the patients died in spite of this step. In most of these cases there was extensive laceration of the lung.

FRACTURE OF THE RIBS.

Fracture of the Bony Portion of the Ribs.—Fractures of the ribs are very common. P. v. Bruns claims that they are second in frequency of all fractures and constitute about 16.07 per cent.; Gurlt claims that they are third, with about 15.9 per cent.; some authors claim that they are about fifth in frequency. The difference is probably explained by the fact that in v. Bruns' and Gurlt's cases ambulatory cases were included.

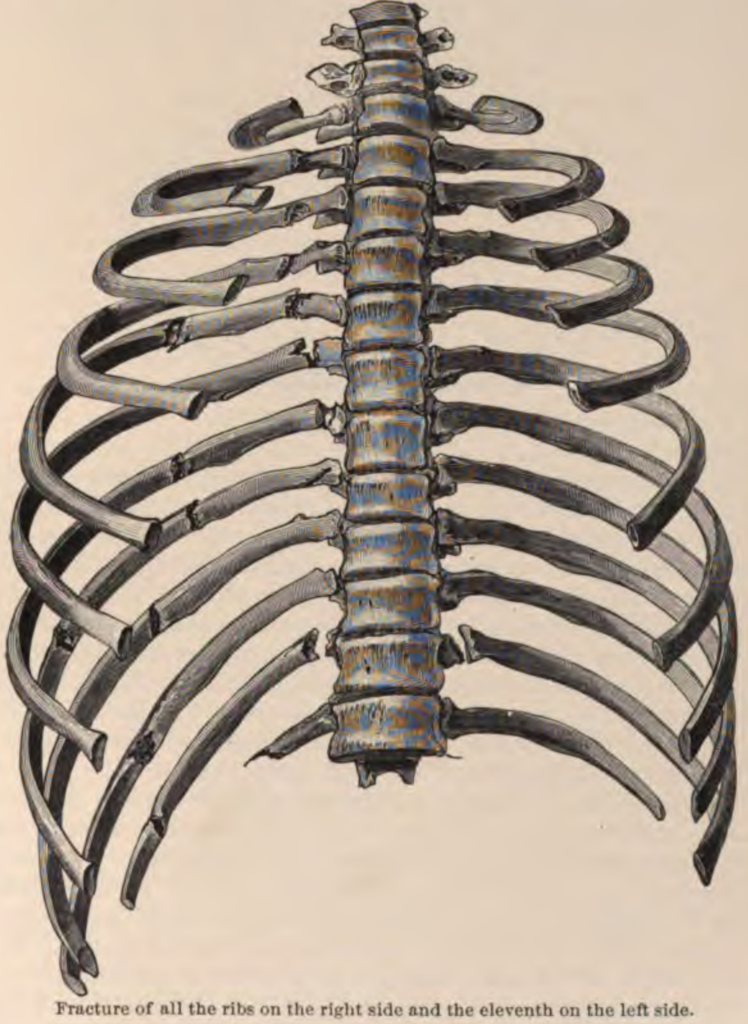
FIG. 143.



Fracture of the second, third, fourth, fifth, sixth, seventh, eighth, and ninth ribs, with consolidation of the sixth, seventh, and eighth, by the excessive callus.

During youth the ribs are very elastic. The sternal and vertebral joints and the cartilage along the anterior portion increase this quality. With advancing age the elasticity diminishes. In old age the ribs are brittle and the cartilage undergoes fibrous change. Many observations prove that ribs have not been broken even when great weight was brought to bear upon the thorax. Most fractures of the ribs take place during the third decade of life. Accidental causes are usually responsible. The fact that fractures are much rarer in advanced years than might be expected on account of the brittle nature of the ribs is explained by the fact that these individuals are no longer actively occupied and are less exposed to fracture than those younger. Concerning the time of life at which fractures of the ribs occur, v. Bruns found, in 31,986 cases, 4 each in the first and second, 60 in the third, 52 in the fourth, 81 in the fifth, 85 in the sixth, 33 in the seventh, 9 in the eighth, and 1 in the tenth decade.

FIG. 144.

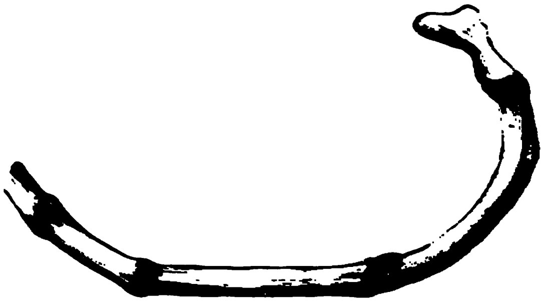


Fracture of all the ribs on the right side and the eleventh on the left side.

The statements of various authors regarding the seat of fracture vary exceedingly. The ribs may be broken at any place. J. L. Petit and Richter found that the middle third was most frequently affected; Middeldorpf and Malgaigne found the anterior portion most frequently involved; and Hamilton claimed that the anterior and posterior thirds are about equally affected, whereas the middle third makes up about one-half of the cases. The author's experience corresponds to that of Hamilton.

The peculiar shape of the ribs explains how all sorts of fractures may occur. There are incomplete, complete, and multiple fractures of the costal arches. Multiple fractures are common. Even four breaks in one rib have been observed. (Fig. 145.) Sometimes the lines of fracture are close together, and at other times they may be far apart.

FIG. 145.



Healed multiple fracture of the rib after being run over by the wheel of a wagon. (v. Bruns.)

The so-called subperiosteal fractures are of especial interest. Their existence was doubted for a long time, although very instructive specimens are now at hand which prove their existence. The periosteum is preserved, although the cortex of the bone is divided. The inner surface shows the same conditions as on the outside. These fractures are due to indirect violence, the pressure being brought to bear from before backward. The line of fracture is separated more on the outside than on the inner surface. The upper and lower margins of the rib are assumed to have separated in some cases. The line of fracture is usually transverse, although diagonal fractures have been reported. The fracture surfaces are rough and extremely irregular.

[illegible] the ribs could be dislocated [illegible] reference to individual ribs. [illegible] displacement repeatedly, [illegible] age, which is not infrequently [illegible]. As an example, he may mention [illegible] had an iron plate fall upon [illegible] in the axillary line. [illegible] fracture, the sternal fragment [illegible] fragment inward.

[illegible] the same time, but rarely [illegible] brought to bear upon the [illegible] equal pressure upon the [illegible]

Compound fractures are uncommon except in case of gunshot-wounds. Fractures of the ribs are not infrequently complicated by other injuries. The anatomical relations explain how the pleura and the lungs are so apt to be injured. Even the pericardium, heart, œsophagus, diaphragm, liver, spleen, and the kidneys have been found injured. When the applied force is very great, so as to compress the thorax considerably, the vertebral column or pelvis may be fractured at the same time. When injuries of this sort are present, the symptoms produced by fractured ribs are of secondary significance.

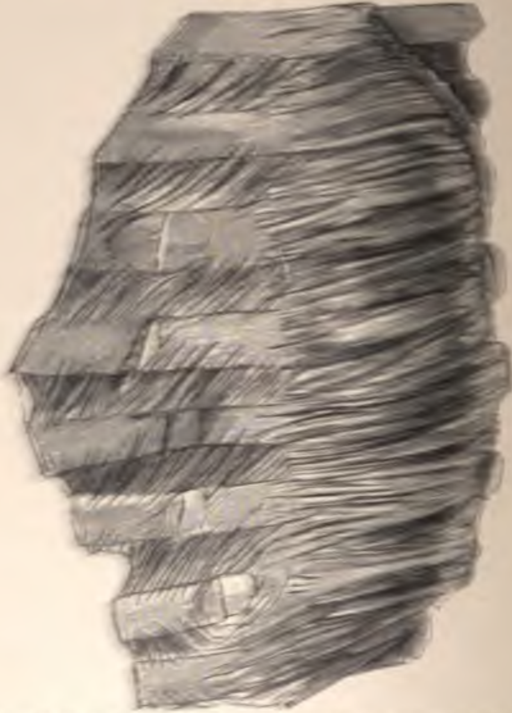
Concerning the frequency of fracture of individual ribs, those exposed most to external forces are most often broken. These are the fifth, sixth, and seventh, whereas fracture of the upper and lower ribs is more uncommon. The first rib is protected by the clavicle, and is rarely broken, which applies also to the eleventh and twelfth. Johnston reports a case of direct fracture of the first rib in which the fragment became separated and produced an abscess of the lung. In the author's experience the floating ribs have been fractured more frequently than the general statement would lead one to believe. The patient usually fell over the back of a chair or the edge of a table, etc. The seat of fracture was almost always in the posterior portion, and as a rule the fracture was indirect.

Concerning the mechanism of fracture of a rib, Petit compares the latter to an arch, the middle portion of which is subjected to some violent sort of pressure (direct fracture), or whose ends are pressed together so that the middle portion is sprung outward (indirect fracture). The thickness of a rib is not uniform, neither is the curve, which accounts for the varying position of the fracture. Ribs may break at any place, although most fractures are in the anterior and posterior sections, rarely in the middle. This depends probably upon the anatomical conditions. The seat of election for all indirect fractures of bones is where there is the least power of resistance, or where there is the greatest amount of curve. In the case of the ribs this is in the posterior region near the angle, and not infrequently close to the vertebral column, and in front, where the bony portion is united with the cartilaginous part. The mechanism is difficult to understand, because the ribs present the greatest possible number of variations normally, and because the seat of compact in the individual rib may vary considerably. It is evident that the upper ribs may be affected differently from the middle ribs, and that these may differ from the lower ribs. A force that affects only the margin of the ribs will have less effect than one which is applied to its flat surface. If the chest is struck by some body with a broad base, the effect will be different from application of this force to a circumscribed area affecting but one or two ribs. The angle at which the force is applied also has some influence. A force applied at an angle will, of course, do less damage than one applied perpendicularly to the surface. The volume of air contained in the lung at the time of injury is also of importance. The age and the changes occurring with age have already been emphasized.

Fractures of the ribs are subdivided into direct, indirect, and th
produced by muscular action.

Direct fractures are more apt to occur when the force applied af
a circumscribed area, and the nearer the line of application to a p
pendicular to the rib, the less chance there is for this to escape. I
evident that for this sort of fracture the chances are more favorabl
the posterior section of the ribs, where they are fixed and less elas
although this type of fracture may occur at any point. The eleve
and twelfth ribs are rarely broken in this manner. The mechanis

FIG. 146.



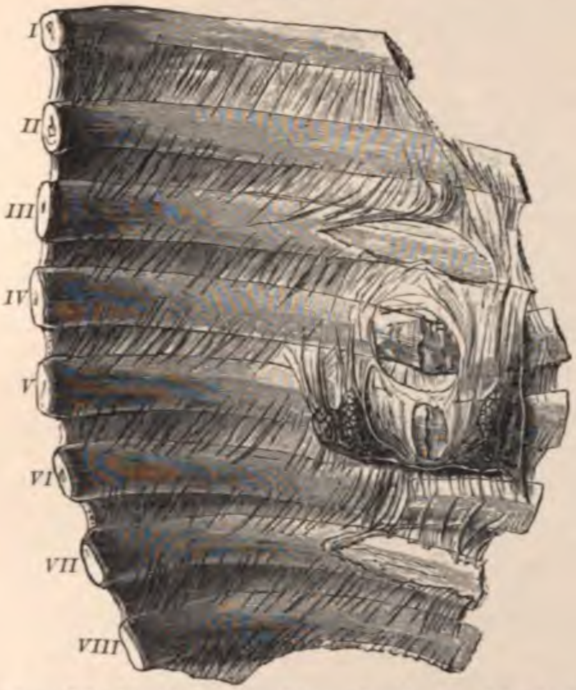
Complete fracture of the fourth and fifth, and incomplete fracture of the third, sixth, an
seventh ribs. External surface.

self-evident. The rib is simply pressed inward, the concave sur
becomes convexed, and as a rule the inner surface breaks first. T
corresponds to the condition found, because the line of fracture is m
more irregular on the inner side than on the outer.

Indirect fractures usually follow force applied laterally, and are m
frequent behind and in front, according to the position of the fo
applied. Sometimes the rib breaks in two places without the s
where the power has been applied being injured in any way. T
means that the rib has been subdivided into two small arches, each
which has snapped at its summit.

After severe contusion in the axillary line the author was able to find a double fracture of the seventh and eighth ribs in the anterior and posterior third. The ninth rib had been fractured in the middle. A double fracture occurs sometimes when the force breaking the rib at the point of contact is not exhausted here, but is sufficient to produce a second break at some distant point. In these cases there are a direct and an indirect fracture—*i. e.*, one break faces inward and the other outward. This theory is corroborated by pathological specimens. Aside from the ragged line of fracture on the inner and external surface of the rib, respectively, the line of the first break is approximately transverse, whereas that of the second is more or less diagonal from before backward and inward. The reverse is the case when the latter fracture is nearer the sternum than the vertebral column. This fragment is not simply cracked out of the continuity of the ribs as was formerly supposed. Double fractures are found usually when the power has been applied to the middle portion of the ribs. As a rule the fragments are pressed inward at the first seat of fracture (direct), and at the second there is a prominence. There is still another possibility: a rib may not only break at the seat where the force is applied, but also in front and behind this point, resulting

Fig. 147.

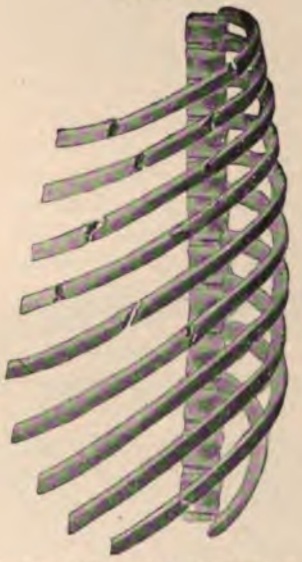


Complete fracture of the fourth and fifth, and incomplete fracture of the third, sixth, and seventh ribs. Internal surface.

in one direct and two indirect fractures. When the force is applied on both sides at the same time, or when the chest is fixed against some firm resistance, then bilateral fractures are observed occasionally. In these cases, of course, the fractures are extensive, and there may be considerable injury of the intrathoracic viscera. Heineke observed twenty-nine breaks in one case. Whereas direct force has a tendency to straighten the rib, force applied from before backward has the reverse effect, and tends to approximate the ends. The curvature is increased outward and the anteroposterior diameter of the thorax is diminished, whereas the horizontal diameter is increased. There is increased tension in the lateral portion of the rib which should theoretically be most pronounced in the middle, but which is more marked in the anterior and posterior thirds of the rib near the angle, but rarely at the angle itself. The ribs are not placed in one plane. They are curved downward, and the force applied never corresponds absolutely to the direction of the ribs. The position of the ribs will be changed by any force applied over a considerable area in the anterior sternal region of the chest. Those ribs that have a triple curve endeavor to escape by assuming the position in which they are capable of offering the greatest amount of resistance—*i. e.*, they present their borders. Even if this is only possible to a moderate degree, the power of resistance is increased. The facts that the ribs rotate somewhat upon themselves and twist from without inward on their longitudinal axis have the same effect. Only when these accessory agencies have been overcome will the power be transferred from the margin of the rib to its flat surface and the bone will break where it no longer offers sufficient resistance. For this reason many fractures have a spiral character in the posterior third, as shown by many preparations. In fractures of the anterior third this will not be so pronounced, because the rotation is not so evident and flat bending of the surface is much more marked. Multiple fractures may arise in this way at any point according to the kind and degree of power applied. This is especially the case in individuals who have been run over. Fig. 145 represents one of v. Bruns' specimens illustrating this mechanism. There is no doubt that in multiple fractures those in front took place first, although there is no appreciable difference in the time interval. The applied force is not exhausted after the first fracture, but is transmitted to the remaining portion of the rib, and breaks this at a place where it can be most easily effected, which is in front. This fracture will not have the spiral character so well developed as fractures in the posterior region of the ribs.

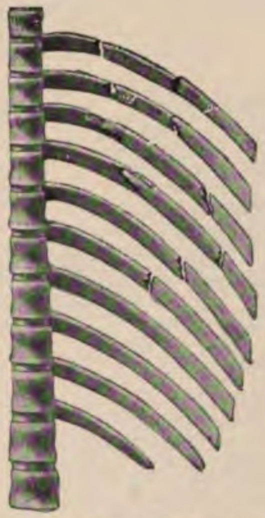
Even a chest that has been fractured will resume its normal position to a considerable extent after removing a heavy weight, especially if the lungs still contain air. This elasticity may be tested on a corpse by plugging the trachea. During life the elasticity and the conditions for resisting force are much better. After some injuries in which the force has been applied evenly, symmetrical fractures occur, although they are not common. It is not frequent to have force applied evenly to the anterior surface of the chest, and both sides of the thorax are not always alike, which is self-evident. These conditions, of course, influence the resulting fractures. Furthermore, the anterior cartilaginous portion of the ribs at each side of the sternum may be very prominent and extend beyond the level of the sternum. In cases of this sort the fractures will be far forward. Conditions are very similar when the power is applied from behind forward, as in Mondière's case. This patient fell on his back and fractured the fourth, fifth, and sixth ribs near their cartilages. When the forces are applied both in front and behind, there is apt to be a very considerable amount of damage. Zwinger reports the case of a man who was run over by a team while lying on the ground. The lower ribs were broken in front and the upper ribs behind. In another case in which a weight fell upon the back of a man, who died sixty hours later, it was found that the third, fourth, fifth, and sixth ribs had been fractured in the mammary line. The sixth, seventh, and eighth ribs had been fractured in the posterior third about 6 cm. from the vertebral column; also the tenth, eleventh, and twelfth ribs. The author has a very instructive preparation (Figs. 148 and 149) of a man whose chest was run over diagonally by a wagon. The wheel probably passed first over the liver and then diagonally over the left half of the chest upward and outward. The liver was lacerated and the right half of the heart torn. Death was immediate. The right side had not been injured, but on the left side was a series of characteristic fractures.

Fig. 148.



Fracture of ribs after being run over.
External surface.

Fig. 149.

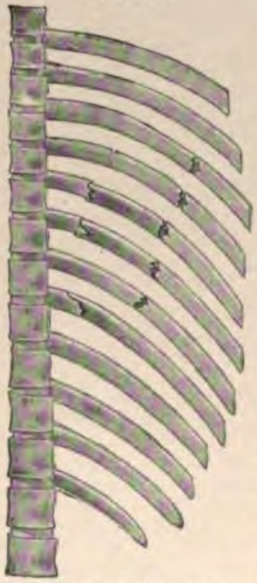


Fracture of ribs after being run over.
Internal surface.

The third, fourth, fifth, sixth, and seventh ribs were fractured twice and the eighth once. The fact that the seventh rib showed an incomplete fracture in the anterior third is characteristic. Only the outer surface had been broken; not the inner surface. The piece broken corresponded to the description given above.

Besides those fractures already described, there remain those due to muscular action. Gurlt has collected 14 cases, and Bähr has added 20 more. Erichsen observed these fractures take place during labor. Stetter reports a case which followed the lifting of heavy weights. The author has seen fracture of the fifth rib at the junction of the cartilage in a young man who threw his hands backward to alight upon all-fours. In this case considerable tension was probably put upon the pectoralis minor. Fracture of the ribs has been reported after slight exertion, such as sneezing or coughing. In these cases the fracture probably took place during the violent expiratory effort. Bähr is probably not wholly wrong in doubting the mechanism above described of some of the fractures. It is a peculiar fact that most of these fractures were on the left side. The author cannot agree with Bähr, at least in cases of the upper ribs, that the liver protects on the right side. Most of these fractures were near the cartilaginous junction in the anterior third.

FIG. 150.



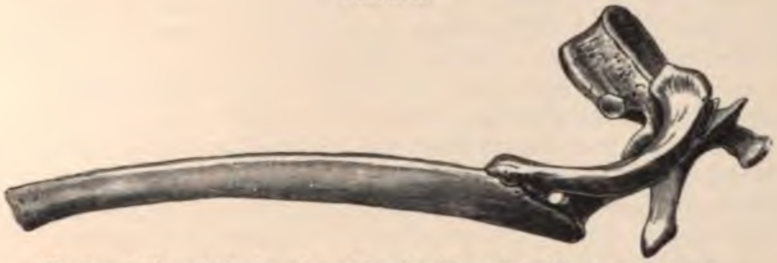
Fracture of ribs due to fall on the left side.

So-called spontaneous fractures deserve special mention. It is well known that fractures of ribs occur in the insane without especial force. In 100 autopsies Gudden observed 16 cases which were mostly paralytic. According to the observations of many authors, the ribs in the insane are frequently so soft that they may be cut with a knife, and anatomically they resemble osteomalacia. Williams found that this was the condition in about half of the insane. Chemical examination by Brown showed that the organic portion was increased at the expense of the inorganic portion, and that the bones resembled the skeleton of the fœtus. It is certain that there is a metaplasia of the bone, and in all probability this is the result of psychoses with more or less pronounced disturbances of nutrition. This makes itself manifest first in the ribs, and also in other portions of the skeleton, and is probably due to insufficient respiration. Muscatello and D. Dosmascelli have shown by experiments that slight activity of the muscles of the chest in paralytics is not without effect upon the bones and usually leads to atrophy. Laudahn reports an insane case with several fractures at the line of junction with the cartilage; several of these united again with exception of the second rib. Chelmonski has reported a series of spontaneous fractures in phthisical patients and cachectic individuals.

Symptoms.—The symptoms of fracture of the ribs depend entirely upon whether there is a simple fracture or whether other injuries are present at the same time. It is not a matter of indifference which rib is fractured, or whether several fractures have taken place at the same time. Some fractures are overlooked on account of the absence of symptoms. Apart from a sharp pain at the seat of fracture nothing is noticed. These injured individuals continue their work.

In most cases the symptoms are characteristic. There is marked pain at the seat of fracture, which becomes evident not only on palpation, but also when the patient takes a deep breath. Sometimes the pain is so intense that the patient cries out even on gentle examination. The most intense pain is usually during inspiration. In many injured the breathing is superficial on account of this symptom: they sit bent forward, with an anxious expression. It is characteristic that pain may be elicited not only by pressing directly upon the seat of fracture, but also by compressing the chest from before backward. The pain will be felt at the seat of injury, which is not the case with simple contusions. In the vast majority of cases crepitus is absent. This symptom may be found by applying energetic pressure, although at times it may be heard on simple respiration. Frequently crepitus may be felt on touching the wound lightly, although subsequent examination fails to demonstrate this cardinal sign. In spite of crepitus, however, it is easy to be deceived regarding the seat of fracture, because the abnormal mobility may be so great that it does not indicate the seat of fracture. Localized pain is the safest guide, although exceptions are found even to this rule. The author has repeatedly observed that in cases of indirect fracture the seat where the force was applied was more tender than the seat of fracture, although in the course of the next few days this relation became altered. In many cases there is abnormal mobility, but with subperiosteal fractures this may be absent. Sometimes there is pronounced dislocation of the fragments, even with single transverse fractures. Displacement may take place in any direction. (Figs. 151 and 152.) Whenever a con-

FIG. 151.



Fracture in the vertebral portion of the rib with torsion of the sternal portion.

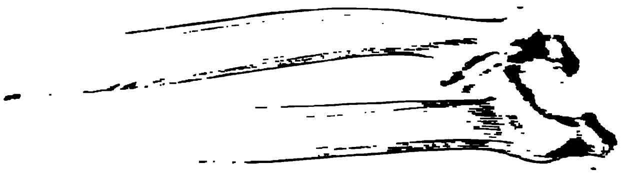
ous with compound fractures. Pneumothorax is much more uncommon than would be expected, although Billroth observed it 4 times in 58 cases. In some of the cases this condition did not appear for several days after the injury. Hæmothorax is generally due to bleeding from the pulmonary vessels. Severe hemorrhage, which always follows laceration of the intercostal vessels, is uncommon in fracture of the ribs.

Hernia of the lung is sometimes noted after fracture of the ribs without external wound. In a case reported by Wahl the second and third ribs had been broken and the hernia appeared some time after the injury during an especially violent attack of coughing. The tumor was extremely painful, so that the patient could not endure any pressure whatever. This hernia reduced itself spontaneously, and the seat could be felt with a finger to be about the size of a five-cent piece. Weiss reports a case of hernia of the lung the size of a fist after fracture of the third, fourth, and fifth ribs on the right side. In Huguier's case the piece of rib that had been broken off did not unite and could be distinctly moved over the prolapsed lung. Vogler reported a case of fracture of the third rib with hernia of the lung in which the mass was about the size of a fist and was very difficult to reduce. The fragments had remained ununited. Similar cases have been reported by other authors.

Diagnosis.—The diagnosis is as a rule not difficult. Occasionally it may happen that a fracture is overlooked, and sometimes a fracture will be presumed present when there is only a simple contusion. When there are fractures of several ribs, it may be difficult to determine exactly the number of fractures, and it may happen that a multiple fracture of a rib is overlooked and supposed to be single. The safest way to examine is to palpate the individual ribs throughout their entire length. In individuals with much adipose tissue this is difficult. Localized pain is characteristic, especially if it is produced by pressure brought to bear from before backward or is marked during respiration. When there is crepitus, the diagnosis is definitely established, and the presence of emphysema is almost of equal value. Pathological mobility is of less value on account of the marked normal elasticity. Abnormal contour and dislocation of the fragments may be of aid at times.

Course.—The course of simple fracture of the ribs is uneventful. The pain diminishes after a short time, breathing is freer and deeper, and in about three or four weeks the fragments will have completely united. With impacted fractures and subperiosteal fractures recovery takes place still sooner. When the pleura is torn, there are not infrequently circumscribed laceration and local adhesions between the opposed surfaces. Sometimes there will be more or less exudate. Neuralgia is not common after fracture of the ribs, although Albers has reported 2 cases that were cured by resection.

Whereas fractures of the upper ribs usually heal without leaving permanent symptoms, the breaks of the lower ones oftentimes are



difficult respiration, morphine subcutaneously is indicated. This method of treatment may be sufficient even with numerous fractures with severe symptoms, such as hæmothorax, cyanosis, emphysema, with weak cardiac activity.

The author has never performed venesection or made use of swathes. Bandages that are tightly applied interfere with respiration and cause considerable pain. Those that are loose slip and serve no purpose whatever. Strips of adhesive plaster that cross the seat of fracture may give relief.

The use of a plaster jacket, as recommended by Sayre, is not uniformly advocated. There is no doubt that good results may be obtained in certain cases, although the same result could in all probability have been reached in some other way. Many patients object to this form of treatment, and the application in severe injuries where it is indicated causes considerable pain to the patient. When there is a fracture of the spine, this form of treatment may be made use of.

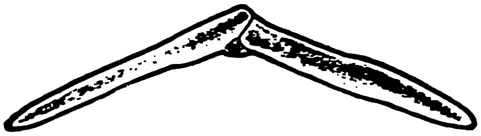
Operative interference may be necessary when splinters have penetrated the lung or when there is marked displacement inward of a fragment which causes annoyance. The seat of fracture should then be exposed and the splinter removed or the fragment resected.

Emphysema does not as a rule demand interference even when very extensive, because it usually disappears spontaneously. Only in exceptional cases will operative interference be indicated. König made an extensive incision with favorable results, and v. Bramann resected one of the broken ribs in a case of this sort, and incised the pleura and drained the same after preliminary puncture. The perforation of the lung, which had not healed, did not correspond to the seat of fracture, but was probably near the root. The drainage-tube was of rubber with thin walls, which opened only during expiration. This patient recovered. The chief aim will be to give free access to the air. When the wound in the lung heals, the pleural cavity ceases to fill with air, the pneumothorax diminishes quickly, and the lung distends again. Any sort of a bandage will prevent aspiration of air from without.

Hæmothorax may necessitate aspiration. When there is a purulent or infected exudate in the pleural cavity, the chest should be opened as soon as possible. In compound fractures the wound should be cleaned as thoroughly as possible, even if it is necessary to resect the rib, and any loose splinters should be removed. An antiseptic or aseptic bandage should be applied, and any subsequent treatment should depend upon the developing symptoms.

Fracture of the Costal Cartilages.—Fracture of the cartilaginous portion of the ribs is much less frequent than fracture of the bony part. Gurlt collected only 30 cases. They are much more common, however, than was formerly supposed. The author has recently observed a number of cases. During youth the costal cartilage is extremely elastic and hardly ever breaks. In the latter years of life changes take place which diminish its power of resistance. The changes above mentioned are chiefly fibrous in nature. Calcification and ossification are uncommon. The fibrous change may be recognized microscopically. Microscopically the fibrillæ may be recognized as fine streaks, and the intervening substance, usually of homogeneous nature, becomes liquefied. There are also some overgrowth of cartilage-cells and disintegration of the cartilage itself. In spite of these changes the cartilage is quite resistant.

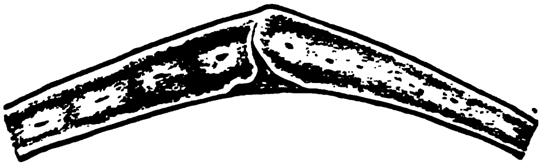
FIG. 156.



Fracture of cartilage with slight formation of bone.

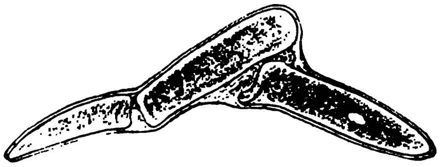
Many fractures of the costal cartilages are due to direct violence, although breaks due to indirect violence, such as muscular action, have also been described. These fractures are with few exceptions unilateral, and correspond to the direction of the fibrous change, so that transverse fractures with smooth margins are produced. Longitudinal fractures of the cartilage are observed only in connection with fractures of the sternum where the line of fracture of the breast bone is continued into the costal cartilage. Multiple fracture of a cartilage has also been reported. Fractures at the line of union between the bony and cartilaginous portion of the ribs should not be included in this group, strictly speaking. Most fractures take place near the seat of union with the bony part, although the term chondrocostal luxation is not applicable, because there is really no free joint. The author has found that the eighth costal cartilage is the most frequently broken;

FIG. 157.



Fracture of cartilage with considerable bone in the line of fracture.

FIG. 158.

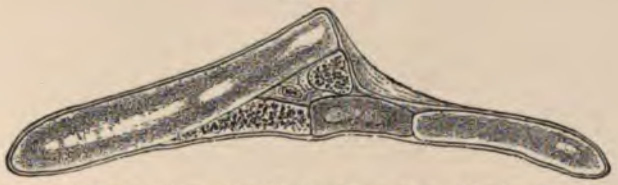


Double fracture of cartilage.

the others quite rarely. Strange to say, the majority of the fractures occur on the left side.

Symptoms.—The symptoms are chiefly those of fracture of the bony portion of the ribs. Dislocation and deformity are sometimes so marked, however, that the injury can be recognized at a distance. It is presumed on the strength of Magendie's view that the sternal fragment is the one generally displaced. The reverse, however, may take place with equal frequency. The sternal fragment is usually displaced inward and the vertebral fragment outward. There is almost always some longitudinal displacement.

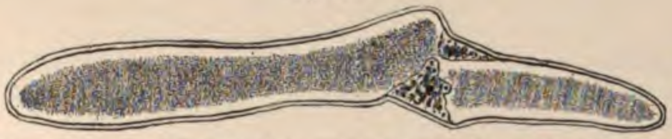
FIG. 159.



Fracture of cartilage with considerable bone formation on the inner and outer side.

Diagnosis.—The diagnosis is as a rule easy. In the region of the vertebral end of the cartilage there may be doubt at times whether there is a fracture of the cartilage itself, or whether there is a separation of the cartilage from the bony portion of the rib. Several views are held regarding the process of repair in fractures of the costal cartilage. Most English authors consider that the cartilage takes part in forming the callus. Schklarewsky believes that connective tissue is formed when suppuration takes place, but that cartilage is formed when union takes place by first intention. Malgaigne, Gurlt, and Hamilton report bony union. As a matter of fact, the cartilage itself does not take part in the process of repair. The perichondrium furnishes the material that unites the fragments, and consists of connective tissue or spongy bone with large spaces. Not infrequently both kinds of tissue are present at the same time. As a rule the connective tissue will be found where the cartilaginous surfaces are in approximation and the spongy bone where the perichondrium is situated. This bony tissue may extend for a considerable distance between the fragments. Union between the bony and cartilaginous part of the rib is always osseous.

FIG. 160.



Fracture of costal cartilage with formation of bone on the inner and outer side.

Prognosis.—The prognosis as regards union is favorable, although pseudarthroses have been observed. The author observed several cases. The tendency to heal is by no means so marked in the cartilaginous portion of the rib as in the bony section, and union is much slower.

Treatment.—The treatment differs in no way from that of fracture of the ribs in general.

DISLOCATION OF THE RIBS.

Dislocation of the ribs is uncommon at either extremity. The fourth rib is the one most frequently dislocated and generally at the chondrosternal joint. Next in frequency follow the fifth and sixth, while only one case of bilateral dislocation of the second rib has been reported. Dislocation forward is more frequent than dislocation backward, the ratio being about 7 to 3. The violence may be direct or indirect. Muscular action has also been reported as the cause. One patient dislocated the fifth and sixth cartilages while kneading dough, and another while throwing his arms backward. The accident may happen at any time of life. Not infrequently dislocation of the costal cartilage is associated with severe injuries elsewhere, such as fracture of the sternum and vertebral column.

Symptoms and Diagnosis.—There are no symptoms of importance if complications are absent. When dislocation forward is complete, characteristic deformity will be noticed. The displacement of the cartilage cannot be mistaken on palpation. In many cases the deformity may be easily reduced, but reappears as soon as pressure is removed. Sometimes there is considerable pain, and in others none at all. Sometimes there is only pain on pressure. The diagnosis is generally easy, though the conditions may be confounded with fractures of the cartilage. The nature of the ends of the fragments and the dislocation will decide the question.

Prognosis.—The prognosis is not unfavorable, although it is difficult to keep the fragments in place. Convalescence occupies about four weeks.

Treatment.—The treatment consists in replacement, which is not easy with posterior dislocations. Negretti threw cold water suddenly into the face of a patient; during the deep inspiration that followed the cartilage slipped forward. The cartilage is best held in place by strips of adhesive plaster or an elastic bandage with a pad at the seat of dislocation.

Dislocation of Costal Cartilages.—Dislocation of the costal cartilages on each other—*i. e.*, at the place where the sixth, seventh, and eighth come in contact—is uncommon. Very few cases are reported in literature, and these are not beyond question. Malgaigne, who described one of these, examined his patient nine years after the injury. Dislocation forward seemed to be a result of marked extension of the trunk. The author cannot imagine how any decided deformity can be produced in this way. Reduction offers no difficulty, and the ends may be held in place by an appropriate pressure-bandage.

Dislocation of the Vertebral Ends of Ribs.—Dislocation of the ribs at their vertebral ends is rare. This condition could not be produced experimentally. This is explained by the anatomical conditions. The joints are so closely united by ligaments that the rib is more apt to be fractured than dislocated. Only forces that are very complicated and violent are able to produce dislocation. Complete and incomplete varieties have been described. Only 9 cases have been reported in literature, most of which relate to the eleventh rib. The twelfth, seventh, fourth, sixth, and tenth have also been dislocated. The complications present are often very grave and lead to death within a short time.

There are no definite symptoms. There may be pain and some difficulty with respiration without other especial sign. The prognosis is not unfavorable even when the dislocation is not reduced. Pain soon ceases, and the treatment is simply symptomatic.

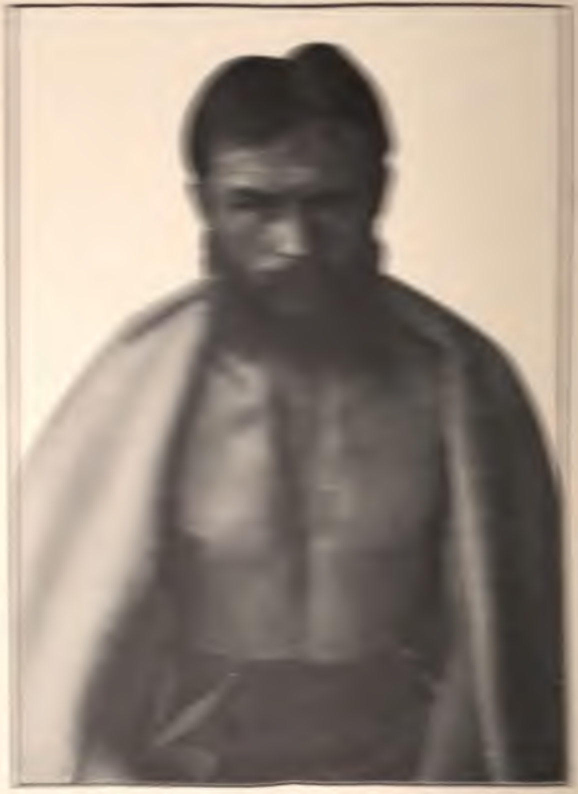
CHAPTER XII.

MALFORMATIONS OF THE THORAX.

By Dr. H. KÜMMELL.

The extensive deformities noticed at birth do not attract the surgeon's attention especially because the offspring is not viable. Th deformities which persist and are of interest here consist chiefly o fissures and defects.

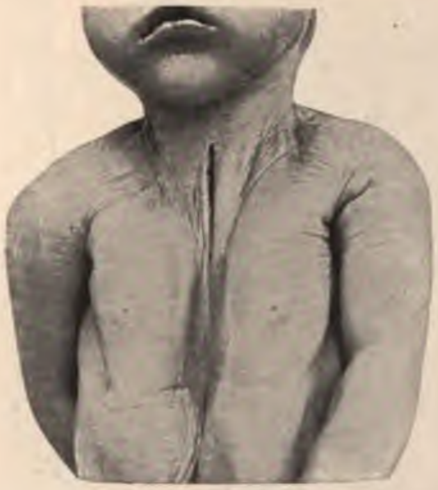
FIG. [illegible]



Congenital fissure of sternum. ([illegible])

Congenital Malformations of the Sternum.—The sternum may be absent partially or completely. The ribs end free or are unit with a fibrous structure which replaces the sternum. Fig. 162 represents a case of complete absence of the sternum. The breast bone is more frequently observed to be fissured, either longitudinally in the middle line or in various other ways. The ribs are attached to the respective halves of the sternum and during respiration the breast bone separates considerably. The amount of separation is greatest at the manubrium and least at the ensiform process, so that the fissure is more or less triangular in shape. Sometimes the sternum is only partially split, usually in the upper segment. In cases reported by Penzoldt and others the fissure was subdivided by transverse bands into two portions. It is not uncommon to have the ensiform cartilage divided into two parts. The sternum is not infrequently perforated in its lower section, a condition which must be taken into consideration in connection with injuries. This deformity is depicted well in Fig. 163. It is much more uncommon to have only one-half of the sternum develop. In this case the ribs will end free on one side. The intervening space will be filled with a membrane that bulges with expiration and is retracted during inspiration. The pulsation of the aorta and the movements of the heart can frequently be seen through this thin wall.

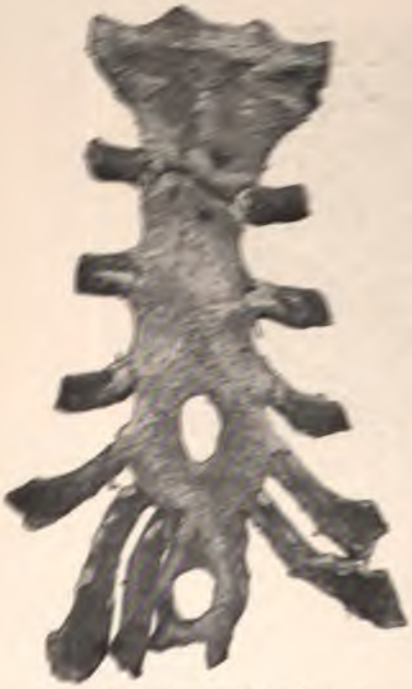
Fig. 162.



Congenital defect of the sternum.

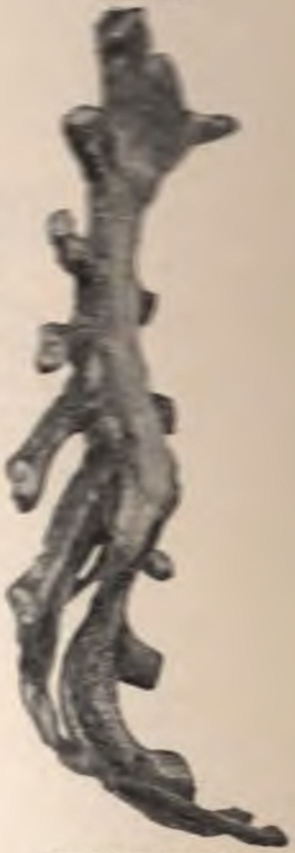
. In rare cases fissure of the sternum and defects of the ribs may give rise to hernia of the lungs. This is observed, however, even without deformity at the apex of the lungs at the side of the trachea. These congenital herniæ must be differentiated from the acquired variety, which are produced by some blunt force acting upon the chest-wall, which tears the pleura and allows the lung to crowd itself through the tear during inspiration. Buntzen reported a case of hernia of the lung in a girl fourteen days after birth, which appeared quite frequently and disappeared spontaneously. [illegible] reports a case of hernia of the lung between the sixth and seventh ribs in a child, which was due to violent attacks of coughing. This swelling, about the size of a large plum, was tympanitic on percussion and showed vesicular murmurs. When reduced, there was emphysematous crackling. With these above-mentioned deformities there are often deformities of the entire chest and vertebral column.

Fig. [illegible]



Congenital perforation of the sternum.

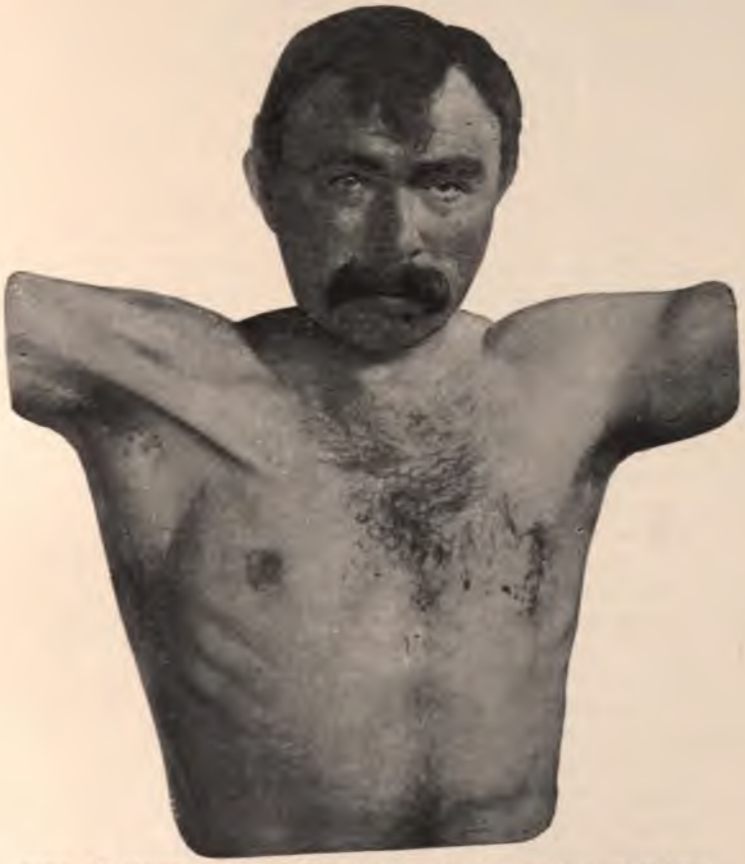
Fig. [illegible]



Funnel-shaped sternum.

Another deformity of the chest is the "funnel chest," to which *Epstein* first called attention. This consists in a funnel-like depression in the anterior chest-wall involving the upper portion of the abdominal wall. The pit is often so large that it is possible to put the entire fist within the cavity. The centre of the defect is a little to one side of the median line. Funnel chests are usually congenital. Very few acquired cases have been reported in literature. Rickets and other diseases are absent in all of the cases. It is interesting that the deformity is confined always to the lower portion of the sternum. Epstein assumes that there has been some retardation of growth in utero, and that the sternum remained in one position for a certain length of time. Fig. 165 represents a funnel chest of moderate degree.

FIG. 165.



Congenital absence of the pectoralis major muscle of right side. (Richardson.)

Congenital Malformations of the Ribs.—One or more ribs may be absent or only rudimentarily developed. Just as in the case of fissures of the sternum, the intervening space is filled by a membrane. Freund reports an interesting case in which three ribs were absent in an infant of eight weeks. On the right side at about the level of the mammary line there was a deep groove about 4 cm. in width extending from the margin of the sternum to the vertebral column. The floor of the depression moved with respiration. Palpation showed complete absence of the fourth, fifth, and sixth ribs. Volkmann, Frickhöffer, Häkel, Seitz, and others have described cases in which the

[illegible]

[illegible] with fixation of [illegible] by v. Eiselsberg in [illegible] fixation of the scapula to the chest-wall or by producing bony union between the scapula along the free margin.

Acquired Malformations of the Chest.—Acquired deformity of the chest is usually due to diseases of the vertebral column or secondary to empyema. Severe scoliosis is almost always associated with marked displacement of the ribs. Rhachitic change of the chest, pectus carinatum, chicken breast, is frequently observed, as well as numerous deformities of the ribs. The deformities which are affected by treatment will be considered in connection with the diseases of the vertebral column that cause them.

CHAPTER XII.

DISEASES OF THE CHEST-WALL.

BOILS AND CARBUNCLES.

THE skin of the back has an abundance of sebaceous glands and is a favorite seat of comedones and acne pustules. A further factor favoring the development of the latter is the fact that the region of the shoulder-blades and the nape of the neck is exposed to continual irritation from the clothing, which may produce inflammation. Treatment consists first of all in care of the skin and removal of any acne pustules that may be present. If boils have developed, which may be very annoying to the patient, hot applications may give relief until the slough has separated. Incisions will be followed by rapid cure. Boils frequently resolve if they have been covered early with a plaster (mercury or carbolic) and protected from friction and pressure.

Carbuncles are of much greater importance, and are always to be considered a severe condition that may under certain circumstances endanger the life of the patient. The favorite seat is the nape of the neck and the region between the shoulder-blades. The skin may be destroyed over an area several inches in diameter, while the necrosis involves the muscles and fascia and even the bones in certain cases (spinous processes and spines of the scapula). The patients always have fever and look ill. The individuals affected are usually advanced in years. In other cases one should always consider the possibility of diabetes, which may be the cause of carbuncles. There is always danger, provided that treatment is not adopted at the right time, that the patients may finally die of sepsis or cachexia.

Treatment.—Aside from the treatment of the original cause (diabetes), energetic surgical treatment should be applied. Total excision of the carbuncle with subsequent antiseptic treatment gives far more favorable results than the crucial incisions formerly used. In excising a carbuncle one should always be as radical as possible. The necrotic tissue is exposed by a crucial incision carried down into the healthy tissue and the sloughing mass is removed just like a tumor. After stopping the hemorrhage the large wound is packed with antiseptic gauze. The base usually cleans rapidly and the defect covers in with epithelium. The flaps of granulating skin should be made use of as much as possible for covering in the wound. Sometimes it may be necessary to apply Thiersch grafts to the granulating areas so as to shorten convalescence. Generally speaking, this step will always necessitate anæsthesia, although in certain individuals it may be accomplished with local anæsthesia.

INFLAMMATIONS OF THE THORAX.

Inflammations of the chest-wall always are of a severe nature. Fortunately they are uncommon. Of 1080 inflammatory processes treated during the last ten years at the hospital in Eppendorf, there were only 26 of this sort. They usually start from some purulent condition of the axillary gland and extend over the anterior chest-wall, either above or below the fascia of the pectoralis major. They may involve the muscle itself, and sometimes rupture externally through the subclavicular fossa. Sometimes inflammation of the chest-wall arises from abscesses in the connective tissue beneath the muscles. These circumscribed collections of pus are as a rule secondary to foreign bodies, such as needle-points, etc.

Even in cases in which there is no such extensive inflammation as above described the result is almost always fatal. The surfaces through which infectious material may enter the system are extremely large compared with those concerned in infectious processes of the extremities, so that the patients succumb frequently within a short time. Of 10 patients treated during the last six years at the above-mentioned hospital only 2 recovered, whereas the others died of general sepsis. Generally speaking, suppuration of the chest-wall tends to rupture externally, and not into the pleural cavity. Duhamel reports a case in which an abscess beneath the scapula perforated the pleura and lung and pus was expectorated. Recovery.

Diagnosis.—The diagnosis of suppurating processes of the chest may be difficult, especially in the early stages. The onset is usually acute with a chill. The only symptom present is extreme tenderness of the entire side of the chest, which interferes considerably with respiration. During this stage the condition may easily be confounded with pleurisy. After several days œdema of the skin, or in more favorable cases circumscribed fluctuation will indicate the true nature of the disease.

Treatment.—The treatment consists in early and extensive incision. If this does not give the desired result, and the fever continues with no improvement of the general condition, it is justifiable to use Marmorek's streptococcic serum. The author's experience with this therapeutic measure does not justify him in advocating this form of treatment generally.

In connection with suppurative processes of the thorax may be mentioned a case of gangrene of the chest-wall, described by Wunder, that developed in the course of an attack of measles. In a child two years of age gangrene of the soft parts developed on the tenth day below the right axilla, and extended downward, involving an area about 4 by 9 cm. The gangrenous portion soon showed a line of demarcation and the slough separated. The skin and part of the muscles had been affected. Recovery ensued. Wunder assumed that the gangrene was caused by embolism of the long thoracic artery.

ABSCESS OF THE CHEST-WALL.

Various sorts of abscesses occur in the chest-wall, and are difficult to distinguish one from another, and are frequently confounded with pathological processes, such as hernia of the lungs, etc.

Acute Abscesses of the Chest-wall.—These may be due to infections from without, as in other regions of the body. Sometimes they develop around foreign bodies that have penetrated the region directly or have lodged there after wandering in the body. These foreign bodies are usually removed with the pus on incision. Finally, hæmatomata, which are due to some trauma, may suppurate and produce abscesses, just as in the thigh, for instance. Acute abscesses due to osteomyelitis of the ribs and of the sternum will be considered later.

Cold Abscesses of the Chest.—Cold abscesses developing in the soft parts have been reported by Krappel, Billroth, Schede, and others. It is doubtful whether these cases are always abscesses of the soft parts alone, or whether they are not due to some carious bone focus that has not been discovered. The anatomical conditions of the large muscles of the back and chest are such that pus readily dissects downward between them. Abscesses frequently form in regions at some distance from the original focus, which may escape detection. It may even happen that the focus itself heals, and that nothing is left but a cold abscess of the soft parts. Cold abscesses may be as large as a child's head.

Treatment.—The treatment of these abscesses consists first in puncturing the same with a medium-sized trocar and washing out the cavity with sterile water or some antiseptic solution, and injecting a 10 per cent. emulsion of iodoform and glycerin. As a rule the secretion will accumulate after a short time, so that this step has to be repeated at intervals of from five to eight days until recovery takes place. If this treatment does not give the desired result, it is advisable to open up the abscess freely and curette energetically. The treatment of cold abscesses connected with tuberculous disease of bones is considered on page 457.

Empyema Necessitatis.—Although this condition will be considered more in detail later, the author feels obliged to mention it briefly in connection with the differential diagnosis. It is easy to avoid confounding this condition with abscesses of the chest-wall if the physical signs of empyema in the vicinity of the abscess are demonstrated to be present by percussion, auscultation, and exploratory puncture.

Peripleuritic abscesses may at times perforate the chest-wall and produce fluctuating tumors beneath the skin. The clinical picture is much like that of empyema necessitatis.

Perforating Abscesses of the Lung.—The conditions are much more difficult with an abscess of the lung which perforates the pleura and chest-wall and points beneath the skin. It may be difficult to arrive at a correct diagnosis on account of the extensive pleuritic adhesions and because the abscess of the lung may be deeply situated. The connection between the superficial abscess and the abscess in the lung may be overlooked. Large phthisical cavities filled with air may rupture through the thoracic wall and form abscesses filled with air and pus. The percussion-note over these is tympanitic. This symptom always indicates communication with the lung or the bronchi. The following conditions must be mentioned on account of their differential diagnostic importance:

Hernia of the Lung.—The tympanitic percussion-note and the variation in size with respiration are of importance in this connection. The tumor might be confounded with abscesses containing air, which give a like percussion-note and vary in size with inspiration and expiration. The fact that hernia of the lung can usually be replaced without difficulty, whereas this is not possible with abscess, is of importance from a diagnostic standpoint.

Cavernous angiomata have been confounded with hernia of the lung.

Aneurisms of the aorta, which will be considered later, have also been confounded with abscesses of the chest-wall. After erosion of the sternum or of the ribs these may present as fluctuating tumors of the chest-wall. As a rule the pulsation present and the murmurs will prevent error, although many cases have been reported in which these cardinal symptoms of aneurisms of the aorta have been absent. It has even happened that the sudden gush of blood following incision was the first indication of the true nature of the disease. In doubtful cases it is always well to aspirate with a small needle before attacking the tumor radically.

OSTEOMYELITIS OF THE RIBS AND STERNUM.

Acute osteomyelitis of the ribs and sternum is rare. Of 11 cases of acute osteomyelitis of short and squamous bones collected by M. Fröhner in v. Bruns' clinic, there is only 1 case, and that of the sixth rib. In cases of multiple osteomyelitis it is not so uncommon to have foci in the ribs or in the sternum. Attention has been recently called to the fact that osteomyelitic processes in the ribs may occur in typhoid, in the course of which inflammatory bone foci have frequently been observed. Bauer has reported 8 cases of this sort. The author has operated on a case. In all of these cases the anterior end of the ribs was affected—*i. e.*, the line of junction between the bone and cartilage, the cartilage itself, or the junction between the cartilage and the sternum. This region seems to be chiefly affected even in cases of primary osteomyelitis of ribs. Considering the small number of cases reported, it is hardly possible to make any statement as to the relative severity of osteomyelitis of the ribs compared with the condition in other regions of the body. It is, however, certain that the abscess that develops has no tendency to perforate the pleura. The treatment consists in free and early incision, and resection of the involved piece of bone or cartilage.

TUBERCULOSIS OF THE STERNUM AND RIBS

Tuberculosis of the sternum and ribs is [illegible] [illegible] in acute inflammatory processes of these bones, although it is by no means so common as tuberculosis of the vertebrae or the long bones of the extremities. According to the statistics of Billroth and Menzel, there were [illegible] cases of tuberculosis of the sternum, ribs, and [illegible] out of [illegible] cases of tuberculosis of bones. Of [illegible] cases of [illegible] tuberculosis treated during the last ten years in the [illegible] at [illegible], [illegible] involved the sternum and ribs. The individuals affected are usually in middle life, less frequently young adults, and most infrequently those of advanced age. Aside from the cases in which tuberculosis of the lung and pleura has extended to the ribs, which should be considered as a secondary tuberculosis of the ribs, primary tuberculous osteomyelitis and primary tuberculous periostitis are the two to be distinguished.

Tuberculous osteomyelitis usually commences as a small central focus which extends slowly to the periphery and involves the cortex of bone in its progress. The process extends rapidly only in exceptional cases. When this takes place, the bone itself is not entirely removed and sequestra are formed. The periosteum in the vicinity of the affected bone becomes considerably thickened, as does the surrounding tissue. An abscess forms within the bone which ruptures externally. If the soft parts overlying the ribs are involved in the inflammatory process, the abscess finds its way to the surface, and a fistula develops which discharges an abundance of pus and leads directly to the central focus. Sometimes there are multiple tuberculous foci with numerous sinuses in one and the same rib, or several ribs may be involved, which will produce the same clinical picture. Riedinger reports a case in which almost all the ribs on both sides were affected, and in which there were about twenty sinuses. In other cases the pus ruptures through the periosteum on the external surface and dissects downward along the fascia of the large muscles of the thorax. Abscesses at some distance from the original focus develop, which may be of considerable size, and the origin of which often cannot be determined clinically.

The second and more common form of tuberculous disease of the ribs is tuberculous periostitis. If the periostitis is on the external surface of the rib an abscess develops that ruptures externally within a short time. The conditions are much more annoying if the periostitis is on the inner side. The pus is unable to find its way outward between the ribs and burrows down the chest-wall and along the costal pleura. Sequestra are uncommon with tuberculous periostitis of the ribs. The periosteum is usually stripped up from the rib for a considerable distance, so that the bone becomes necrotic and is a source of prolonged suppuration. The inflammation begins in the perichondrium more frequently in cases in which the costal cartilages are involved. When the disease has persisted for a long time, the costal cartilage involved may be entirely destroyed and recovery follow. The cartilage is replaced by fibrous scar-tissue. Sometimes the process extends to the junction between the sternum and cartilage, which is always an unfavorable complication. Generally speaking, the same applies to tuberculous disease of the sternum as to tuberculosis of the ribs. The destruction may involve the entire sternum. The pus will generally find its way to the surface, because the lining membranes on the posterior wall prevent rupture into the mediastinum and pleural cavities. Sometimes, however, rupture does take place into the mediastinum, which is always followed by a fatal termination. Cases of this sort have been repeatedly reported.

Diagnosis.—The diagnosis of tuberculous disease of the ribs and sternum will not be especially difficult in cases in which there is a sinus opening in the vicinity of the primary focus. Denuded bone may usually be felt with a probe. The conditions are quite different when the abscess has burrowed downward for a considerable distance. The radiograph may be of value in these cases in determining the original seat of disease. After preliminary puncture of the abscess iodoform glycerin is injected under a moderate amount of pressure. This substance is impermeable to the *x*-rays. It will distribute itself in the fistulous tract in the most remote angles, and the fistulæ may be traced on the plate up to the original focus.

Prognosis.—The prognosis of caries of the sternum and ribs varies with the individual case. As far as life is concerned, it is usually favorable, because general infection with tuberculosis does not seem to be so common in these bones as in the long bones of the extremities. In individual cases, however, there is prolonged suppuration, and the patients may finally succumb to secondary conditions. It should always be taken into consideration that tuberculosis of the ribs and sternum is frequently combined with progressive phthisis, and that the patients may die of this condition before the bones have a chance to heal. The prognosis as regards a permanent cure is favorable, generally speaking, because the condition usually heals completely under appropriate treatment.

Treatment consists in early opening of the fistula and resection of the diseased ribs. If the fistulous tract is extremely long, it is always best to try iodoform glycerin injections. This method of treatment is frequently sufficient; and provided the results are negative, one can always resort to opening up the entire tract and attacking the original focus. In the case of the sternum the desired result may be obtained not infrequently by incision and thorough curetting. Henke reports 10 cases of this sort in Helferich's clinic, all of which were cured or improved. In severe cases it may be necessary to undertake an extensive operation and resect a portion of the sternum and the ribs that are involved. The author has personally performed several resections of this sort in which it was necessary to expose the pericardium for a considerable distance, and has had recovery follow. The large defect was closed as much as possible with skin, and sliding flaps were made if necessary. The small granulating surfaces that remained were covered in by skin-grafts.

SYPHILIS OF THE STERNUM AND RIBS.

Aside from secondary syphilitic lesions of the skin and soft parts that are frequently found on the chest and back, there may be late lesions of syphilis affecting the ribs and sternum. Clinically these lesions resemble those of tuberculous disease of the bone and frequently cannot be distinguished from them. Contrary to tuberculous inflammation of the ribs, syphilitic inflammation usually develops from the periosteum. A spindle-shaped tumor will be found at the seat of disease. The process extends along the rib, and purulent coagulation-necrosis and extensive necrosis of the bone follow. Sometimes the sternum shows extensive destruction that resembles the conditions found in tuberculosis. Gummatous swellings may sometimes be observed, and may be confounded with tumors of other origin. Köster excised a tumor of the sternum that was supposed to be sarcoma, but was shown later to be a gumma.

Diagnosis.—It has been emphasized that in tuberculous disease the pus is more apt to be caseous and flocculous, whereas in syphilitic processes the pus is tenacious and homogeneous. The presence of other syphilitic signs will be of importance diagnostically, although they are absent in many of the cases. Too much importance should not be attached even to the presence of other syphilitic data, because it is well known that syphilis and tuberculosis may be present at the same time.

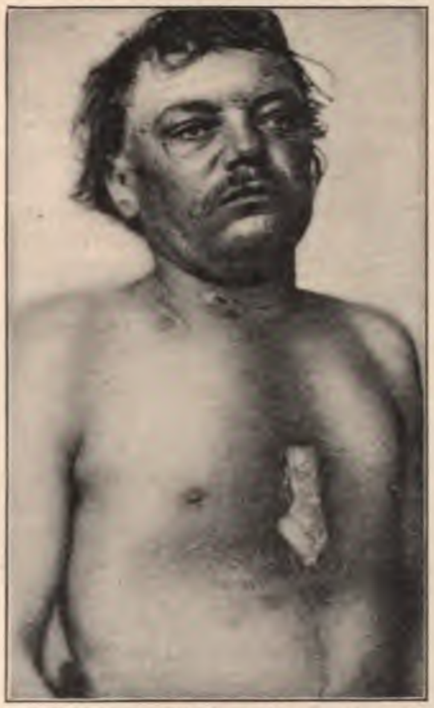
Treatment.—The treatment of syphilitic processes of the ribs and sternum does not differ surgically in any way from that described in the preceding chapter, although general antisyphilitic treatment should, of course, be applied. Potassium iodide should be given in large doses (150 to 300 grains daily), and will often give the desired result. Sometimes inunctions will aid recovery. In several cases of syphilis of the bones in which this form of treatment did not give the desired result, the author observed good results after the use of Zittmann's decoction.

ACTINOMYCOSIS OF THE THORACIC WALL.

Since the discovery of actinomyces the number of cases reported from year to year has increased on account of the general distribution of knowledge of this condition and the greater ease of making a diagnosis. It is self-evident that the thorax will be attacked with great frequency by actinomycosis. Infection through the mouth, pharynx, and lungs is of importance in connection with disease of the chest-wall. It is well known that caries of the teeth is an especially predisposing element in this condition, and several cases have been reported in which bits of carious teeth have been found in actinomycotic lung abscesses.

Symptoms.—Actinomycosis in man is characterized by its tendency to progress rapidly and persistently. An abscess develops at the original seat of the disease and fistulous tracts form in all directions which establish new abscesses everywhere in the surrounding tissues. If infection has taken place through the pharynx, the process soon attacks the soft parts of the neck and rapidly burrows downward toward the chest. With primary disease of the lung, the clinical picture corresponds closely to rapidly progressive phthisis. The lung and pleura and the chest-wall become involved by the destructive process. Multiple abscesses develop beneath the skin or a progressing infiltration, brawny and not sharply outlined, manifests itself, which has frequently been considered to be a chronic suppurating process. Generally the patients die on account of persistent extension of the disease. They either succumb to the processes of destruction within the lung itself or death is due to cachexia or amyloid disease of the abdominal viscera, because of prolonged suppuration.

Fig. 166.



Actinomycosis of the lung, thorax, and neck.

Diagnosis.—The diagnosis of actinomycosis can only be certain after microscopical examination. This offers little technical difficulty and is decisive in any given case. One should never procrastinate where there is suspicion of actinomycosis, and there is always suspicion of actinomycosis with abscesses of the chest or with chronic inflammation combined with pulmonary signs.

Prognosis.—The prospects of recovery in actinomycosis of the chest are slight if it has extended from the pharynx to the lungs or to the thoracic wall.

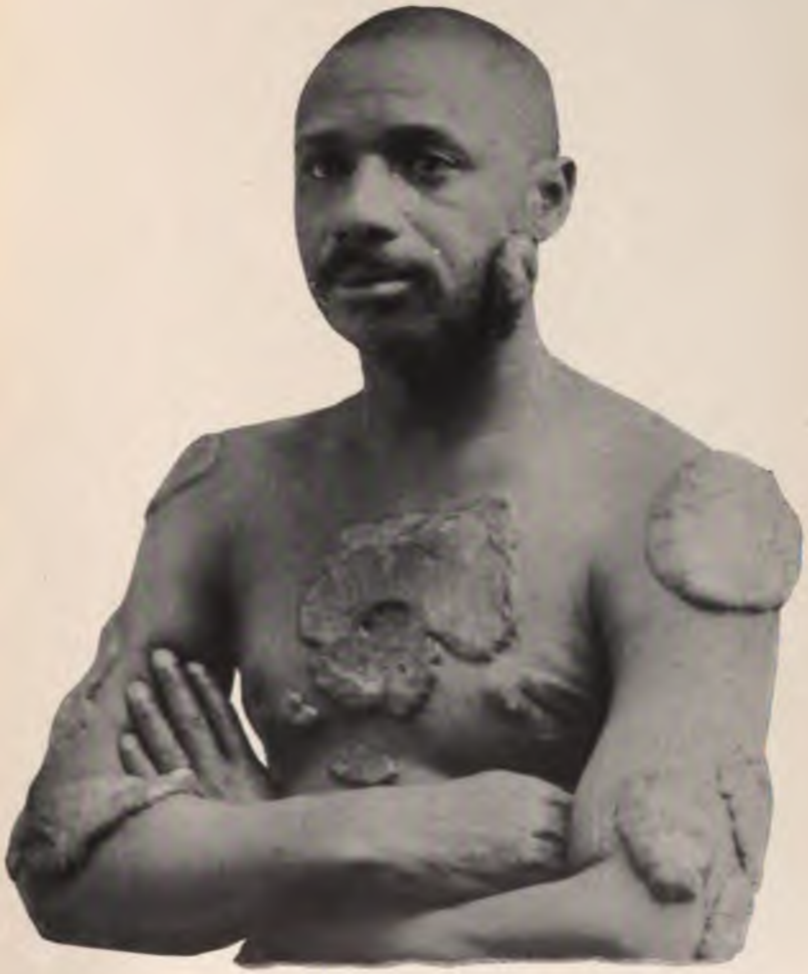
Treatment.—In individual cases recovery may follow incision and washing out of the fistulæ with strong disinfecting solution. Billroth reports a case of actinomycosis that recovered after injection of Koch's tuberculin, although this measure has been of no value in the hands of other observers. The author has seen improvement repeatedly after the use of potassium iodide, and believes that this drug should be made use of, especially as it does no harm to the patients.

INTERCOSTAL NEURALGIA.

Neuralgia of the intercostal nerves is a disease of middle life. Aside from the cases of neuralgia in hysteria or neurasthenia, intercostal neuralgia is observed as the result of "catching cold" or in connection with infectious diseases, and is more common in women than in men. Neuralgia is frequently the result of some destructive or deforming process. It is present in caries of the ribs, spondylitis, tumors of the ribs and vertebral column which press upon the nerves, and also as the result of arthritic curvatures of the column. The pain is usually limited to one side, although several nerves are involved as a rule. It begins in the back and radiates along the ribs to the front of the chest or to the abdominal region, and may be so violent that the patients avoid movement, especially those of respiration. Herpes zoster is frequently associated with this disorder.

Treatment.—The treatment is directed first of all to the primary cause (spondylitis, caries, etc.). If no such condition is present, or if treatment is ineffectual, internal medication should be considered. Nussbaum was first to attack intercostal neuralgia surgically, and observed benefit follow exposure and stretching of the affected nerves. Later Schede resected the intercostal nerves, a method which has been of considerable value in the author's hands. As a rule several nerves will have to be divided, so that it is best to make an incision parallel to the vertebral column and about 5 cm. from the middle line. It is not advisable to make the incision farther forward, because the intercostal nerve very soon divides into two branches, the anterior and the posterior. After exposing the intercostal spaces the costal muscles are divided and the nerve separated from the artery and vein, which lie above. The nerve is best removed by extraction, as recommended by Thiersch for the trifacial. It may be torn out in this way for a considerable distance in both directions. This method of treatment is to be recommended when other means have been ineffective.

PLATE XII.



Keloid.

TUMORS OF THE CHEST-WALL.

A variety of tumors are found on the chest-wall which develop partly from the soft parts, partly from the bones or periosteum. New growths in the vicinity, such as carcinoma of the breast, attack the chest-wall frequently. In this chapter will be considered only those tumors that develop in the chest-wall itself.

Benign Tumors.—Ephelides and **nævi** occur on the skin of the back and chest, just as in the skin of the face and arms. As a rule they are of no clinical importance. Nævi, however, especially the so-called nævi pilosi, which are large pigmented areas with abundance of hair, may become the object of surgical interference for purely cosmetic reasons. The author observed in a child three years of age several nævi of this sort which were as large as the palm of a hand and were distributed over the chest and back.

TREATMENT.—For the purpose of removing these growths excision is recommended. This should be carried down into the subcutaneous tissue and the defects covered in with sliding skin-flaps. Sometimes a favorable result follows daily exposure to the Röntgen rays for about fifteen minutes. This is usually followed by falling out of the hair. This form of treatment must be applied cautiously, because deep burns are likely to follow which show little tendency to heal.

Sebaceous cysts and **dermoids** are also observed on the chest, especially on the back. They may be at times confounded with abscesses and other cystic tumors. The method of growth and development will usually enable a correct diagnosis.

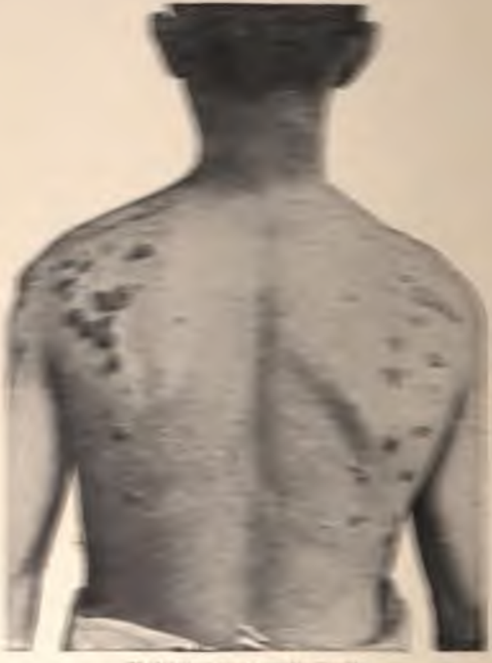
TREATMENT.—These small growths may as a rule be easily removed under local anæsthesia.

Keloids.—The skin of the chest is sometimes the seat of keloids, which appear in considerable numbers (Fig. 167) as dense pink or gray elevations with an irregular nodular surface. The cut surface shows them to be of fibrous consistence, and microscopically they show little difference from fibroma or hypertrophied scars. The old method of distinguishing scar-keloids and spontaneous keloids no longer applies, because Wilms has demonstrated that even when a keloid is covered with epidermis the growth is due to injury of the cutis with subsequent scar formation. A special variety of scar-keloid is that developing at the seat of acne pustules. This variety probably explains multiple keloids of the back and chest, because acne is most numerous in this region. There is usually some individual predisposition for the development of keloid, because people who have keloid of one wound are apt to develop the same condition in any subsequent scar. Keloids of the chest-wall rarely give rise to symptoms, although at times they may be the cause of violent neuralgia.

TREATMENT.—As far as treatment is concerned, surgical interference should be avoided. A new keloid develops after excision, which is, of course, larger than the primary growth, because the tumor is dependent upon the size of the scar in which it develops. Galvanocaustic and electric treatment have similar negative results to repor Sometimes keloids disappear spontaneously.

Lipomata are the tumors most frequently found on the chest-wal They are usually found on the back and vary considerably in siz Billroth reports a case of lipoma that reached from the scapula dow to the calf of the leg and was about the size of one's thigh at its be and twice as large at the bottom. It was carried in a bag by th patient. As a rule, lipomata of the chest-wall are subcutaneou although they have been reported beneath the muscles, for instan beneath the pectoralis. They are always encapsulated and lobula

FIG. 167.



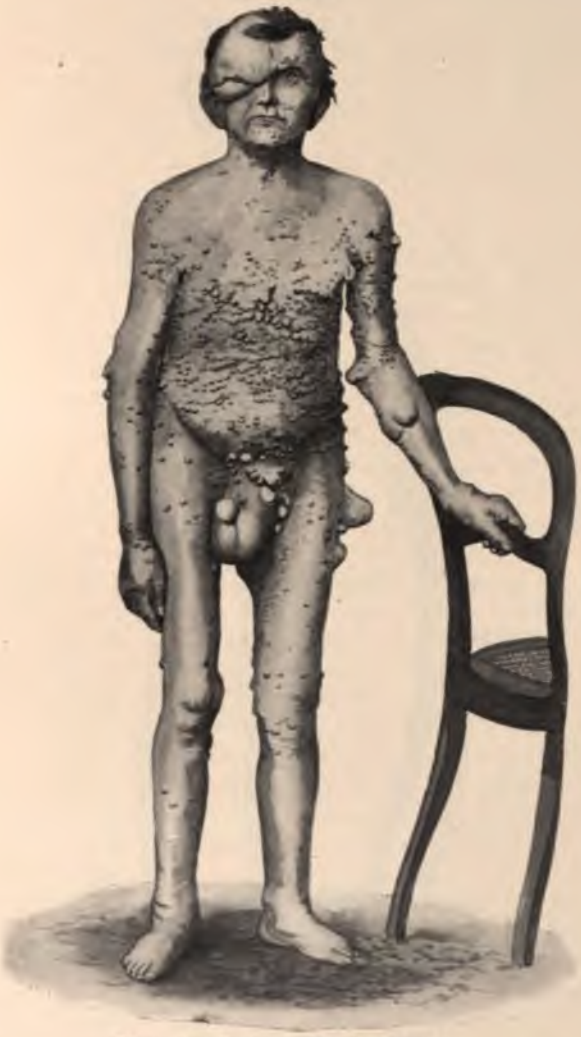
Multiple keloid of the back.

Most of these growths have a broad base, although at times they ma have a narrow pedicle, a type that has been termed lipoma pendulum. Retromammary lipomata deserve especial mention, because the cause gradual disappearance of the gland-tissue by pressure and involv the breast correspondingly. These cases may resemble hypertrophy o the breast very closely.

SYMPTOMS.—The symptoms produced by lipoma are at first sligh With increasing growth, especially when they are over the scapul they interfere with the movements of the arms. Very large lipomata, as Billroth's case, are a nuisance to the patients simply on accoun of their size and weight.

DIAGNOSIS.—The diagnosis of lipoma is usually easy. Care mus be taken not to mistake fatty tumors with broad bases for abscesses or cystic tumors, because these lipomata are apt to be soft and of doughy consistence, whereas the latter fluctuate. The nodular nature of the growth can usually be detected on palpation. Lipoma pendulum will always be easy to detect.

FIG. 168.

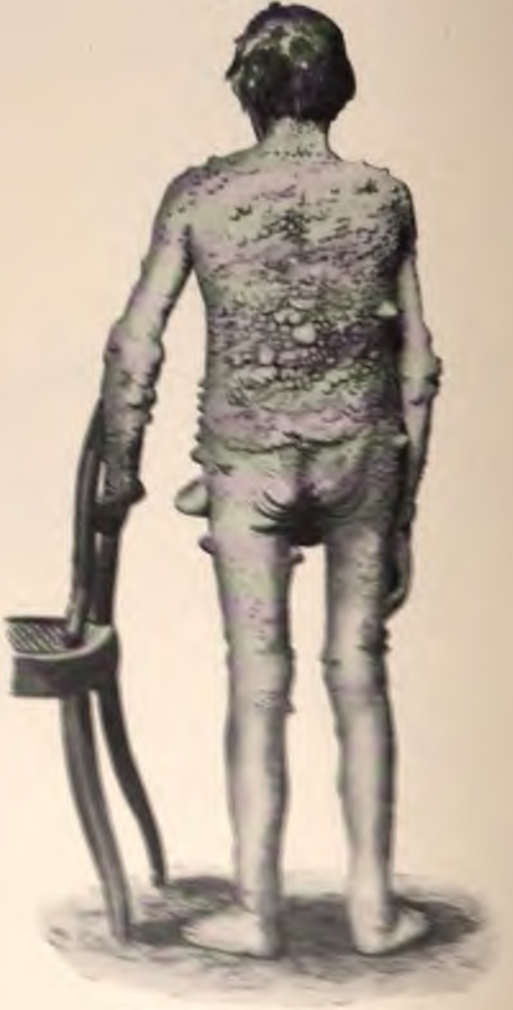


Fibroma molluscum. Front. (Lesser.)

TREATMENT.—The treatment consists in excision of the growth, which is usually easy. With large lipomata it is advisable to resect the excess of skin and leave a drainage-tube in the lower angle of the wound for twenty-four to forty-eight hours, because secondary hemorrhages are apt to occur into the cavities left after excision of the tumors. This hematoma may interfere with convalescence.

Fibroma.—This variety of tumor is met with next in frequency the chest-wall. Fibromata are usually seated beneath the muscle lay and are not very movable compared with lipomata. They are of den

FIG. 169.



Fibroma molluscum. Back. (Lesser.)

consistence and grow slowly. Sometimes the soft parts over a fibrom become inflamed and ulcerated on account of pressure. Extension from a fibroma may involve the pleura, in which case the diagnosi will be difficult, as is also the treatment. The diagnosis is indefinit by the size of a fibroma, which will hardly exceed that of a walnut, combined with its slow growth and the comparatively early appearance of discomfort produced by pressure. Weinlechner excised a submuscular fibroma as large as an ostrich egg which reached from the seventh to the twelfth rib. A second variety of fibroma frequently seen is the fibroma molluscum. This variety is usually subcutaneous, and according to the investigations of v. Recklinghausen develops in the sheaths of nerves. These fibromata are extremely soft, so soft that they sometimes resemble small pouches in the skin, and have been called cutis pendula. Fibroma molluscum is always multiple and may involve the entire body. A case of this sort, which was hereditary, has been reported by Lesser. (Figs. 168 and 169.) These cases cause the individual discomfort aside from the deformity, which is not the case with single scattered subcutaneous fibroma.

TREATMENT.—It may be difficult indeed to excise a submuscular fibroma. If the pleura has been involved, it is always necessary to resect a portion of the same, which may be done without great danger with proper asepsis. Fibroma molluscum may be removed without an anæsthetic by snipping off with scissors. When very numerous this may be done at repeated sittings.

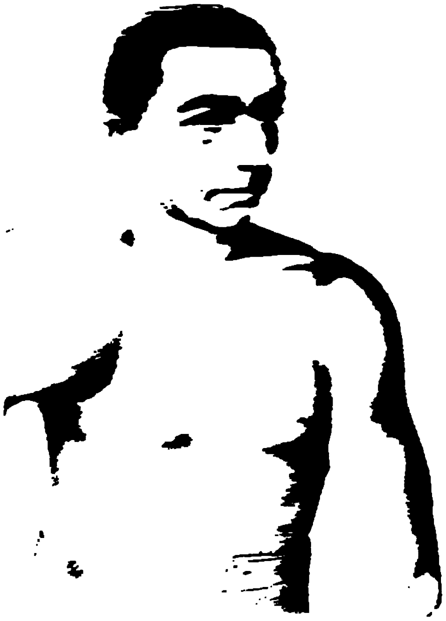
Neuromata.—These tumors are closely related to fibroma, because, as already mentioned, subcutaneous fibromata develop from the nerve-sheaths and should really be called neurofibromata. Other types of neuroma, such as plexiform neurofibroma, occur in the chest-wall. Riedinger has reported a case of this sort, and Pomorski has also observed a similar condition of the intercostal nerves.

Telangiectases and **cavernous hæmangioma** are found on the chest next in frequency to the head. They appear as flat nævi slightly elevated above the level of the skin and are of bright-red or dark-red color. They may be of considerable size, and in individual cases have been known to cover a large portion of the chest-wall or form tense cystic tumors, the margin of which is lobular, which has led to their being mistaken for lipoma. These cavernous angiomata are frequently of considerable size at birth. Billroth excised an angioma of this sort as large as a hen's egg from the back of a child six months old. The tumor usually remains stationary for a considerable time and then develops quite rapidly.

TREATMENT.—Whereas flat telangiectases of the skin hardly ever are the subject of interference, an operation is indicated in the cavernous variety as early as possible on account of their tendency to increase suddenly in size. Sometimes a favorable result is obtained by simply destroying the angioma with a cautery, although it is not uncommon to see the tumor grow again after this sort of interference. Radical excision with a knife with subsequent suture is to be preferred, or, if necessary, the defect may be closed with sliding skin-flaps.

Lymphangiomata of the chest-wall usually develop from the lymphatic vessels in the axilla and extend beneath the pectoral muscles. In common with the angiomata, they are apt to increase suddenly in

[illegible]

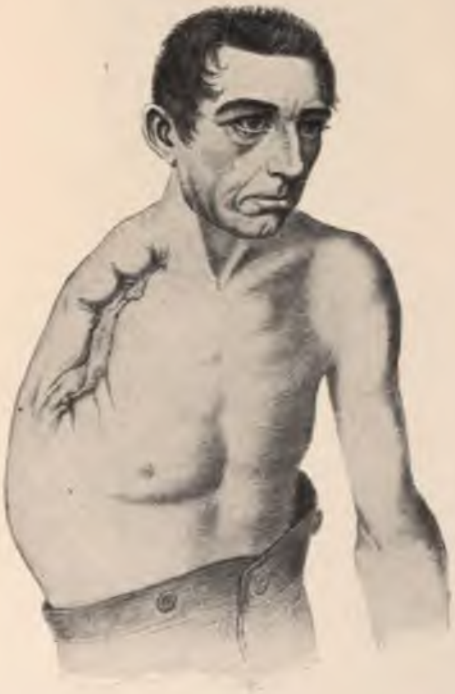


[illegible]

[illegible], especially in the

[illegible] forms the link between benign [illegible] It has frequently been observed that enchondromata have metastases in the surrounding regions, and that they recur after excision. They resemble histologically in a great number of cases the sarcomata (chondrosarcomata), so that it is almost impossible to separate them from these tumors. Compared with enchondromata of the bones of the extremities, those of the bony thorax are relatively uncommon. Weber found only 7 tumors of this sort of the ribs in 237 enchondromata. Enchondroma of the sternum is still more uncommon, and always involves the body of the sternum. When the ribs are affected, the growth develops usually at the line of junction between the bone and cartilage. It appears first as a small hard tumor that grows slowly but persistently until it has attained enormous dimensions. In their interior they are apt to undergo myxomatous degeneration, so that tumors that were originally hard finally appear as large cysts. With increasing growth they extend to their surroundings and may completely obliterate several ribs. The tumor perforates the pleura and extends to the diaphragm or even to the lungs.

FIG. 171.

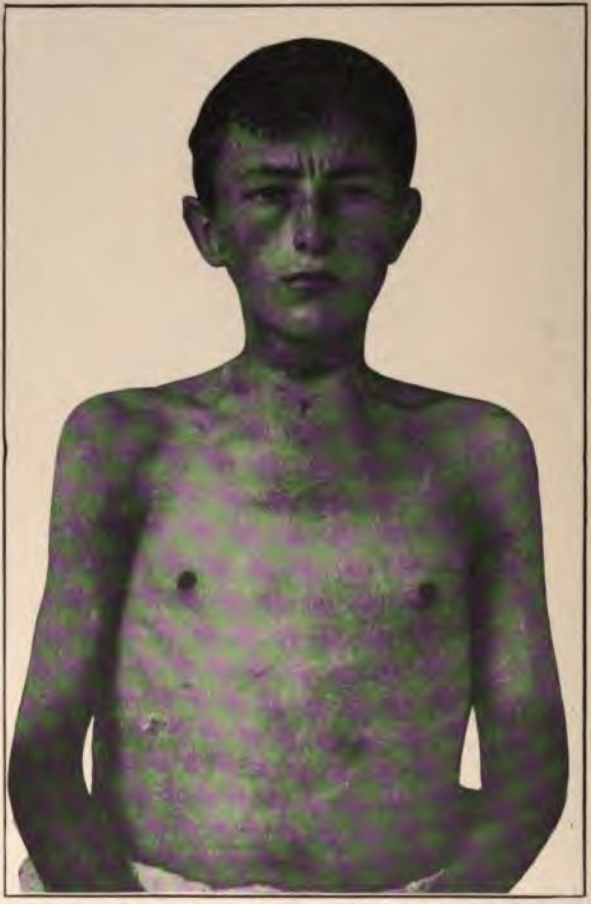


Sarcoma.

ETIOLOGY.—Although obliged to assume that enchondromata are of faulty congenital origin, it is not to be denied that the direct cause of growth is oftentimes some trauma. After fracture of the ribs enchondromata have been observed to develop just as after contusion of the ribs or of the sternum. Cases of this sort have been reported by Heyfelder, Maas, and others. There is no positive proof that trauma is of etiological significance, because it is possible that the injury only hastens the development of a tumor that had already existed.

SYMPTOMS.—Although the symptoms produced by enchondroma are usually slight at first, they increase with the growth of the tumor, and when it involves the surrounding structures marked symptoms of pressure may be present. Enchondroma of the sternum frequently involves the mediastinum.

FIG. 172.

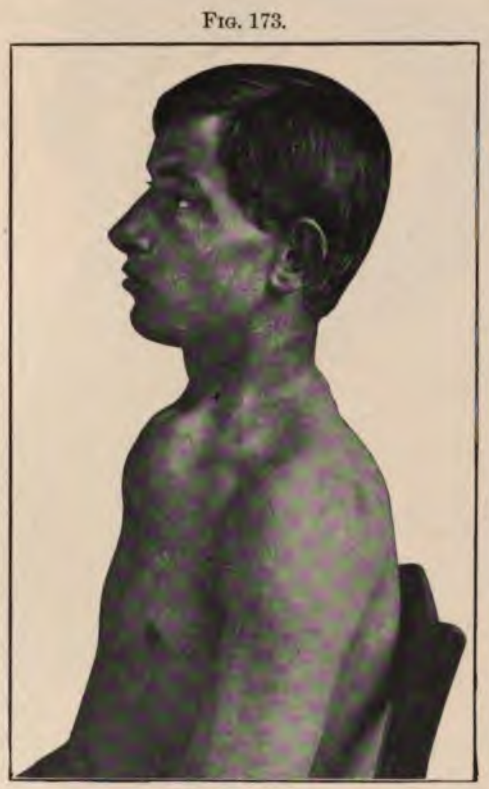


Sarcoma of the sternum. (Curschmann.)

PROGNOSIS.—If the progress of the growth is not limited by excision, the patients finally die on account of involvement of the pleura or mediastinum and pressure upon vital organs. Sometimes metastases are the cause of death. The prognosis of enchondroma is extremely unfavorable. Most of the patients come for treatment when the condition has advanced so far that even after excision the growth is liable to recur or give rise to metastases.

TREATMENT.—The treatment of enchondroma consists in early and radical excision of the tumor. Even when several ribs are involved, the pleura may still be intact, and may be dissected off without injury while resecting the ribs affected. If the pleura has been involved by the tumor, it must be resected to a greater or less extent. Operations of this sort were done in the pre-antiseptic period, although they were dreaded on account of the danger of pyæmia. At present this danger is less, and even pneumothorax is not to be dreaded to such an extent as to render a radical operation inadvisable. With enchondroma of the sternum the latter should be resected. König's case demonstrates that this may be extremely difficult at times. He resected the body of the sternum for osteochondroma, and was obliged to open both pleural cavities as well as the pericardium. This case recovered.

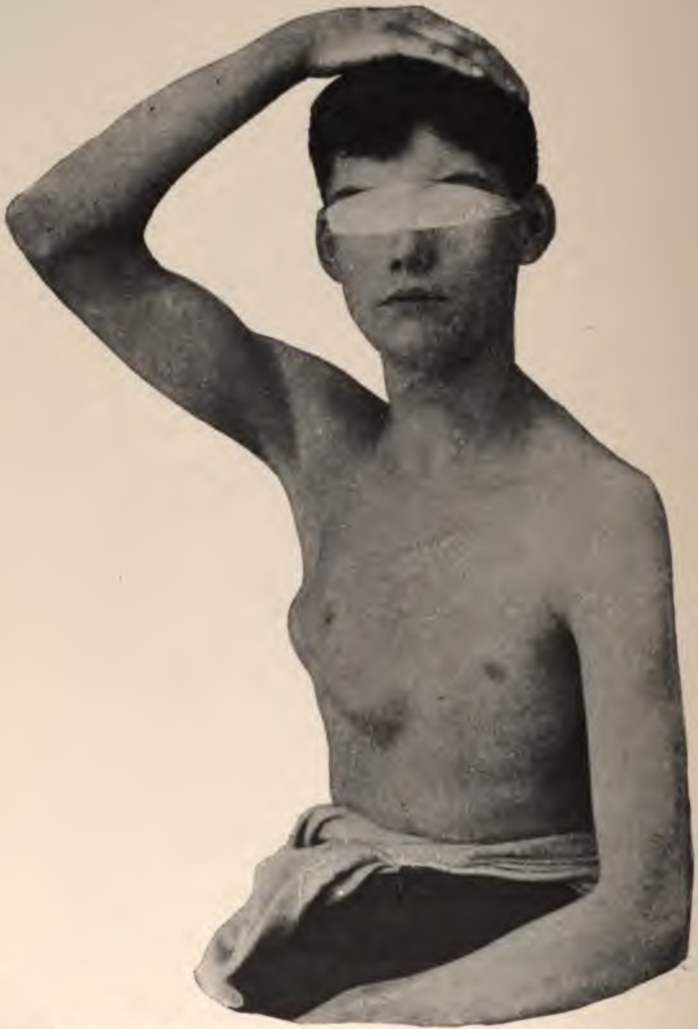
FIG. 173.



Sarcoma of the sternum. (Curschmann.)

Malignant Growths.—**Sarcoma of the Chest-wall.**—Aside from secondary sarcoma of the chest-wall developing from primary growths of the breast, the mediastinum, or of other organs, primary sarcoma of the ribs and sternum and of the soft parts of the chest-wall has been reported. Sarcomata of bones are divided into osteosarcoma and chondrosarcoma. In a previous paragraph was indicated the close relationship between enchondroma and sarcoma, and the traditional varieties mentioned. True sarcomata differ by their rapid growth and the tendency to early development of metastases. External examina-

FIG. 174.



Sarcoma of rib and pleura, result of injury by a baseball. (Dennis.)

tion never reveals the true size of a sarcoma of the ribs, and nowhere does the surgeon become more disagreeably surprised during the operation than in cases of this sort. In spite of this fact an attempt at excision should be made, because sarcoma of the ribs results fatally within a short time if left alone. Quenu and Longuet take this stand in their treatise on tumors of the ribs and sternum. Sometimes a central sarcoma of the ribs develops that pushes the cortical layers outward during its growth and forms a spindle-shaped enlargement of the ribs. This variety produces symptoms quite early, such as intercostal neuralgia, which makes the prognosis much more favorable. Sarcomata of the soft parts of the chest are rare. They appear as multiple tumors with marked surrounding infiltration and have a tendency to disintegrate. (Waitz, Körte, Billroth, Riedel.) The prognosis of sarcomata of the skin is not favorable. As a rule they recur within a short time even after most radical excision and involve the deep-seated structures.

Carcinomata of the Chest-wall.—These occur secondarily to growths in the mediastinum, or more frequently to cancer of the breast. They spread laterally with considerable rapidity or penetrate the underlying tissues and involve the ribs and pleura. A special type of secondary carcinoma of the thorax will be mentioned here on account of its peculiarities: It sometimes happens that a superficial scirrhus of the breast spreads in the skin very rapidly and surrounds the chest as it were with a stiff cuirasse—cancer en cuirasse. Primary cancer of the thorax occurs only as skin epitheliomata, which are much more frequent than sarcoma. They develop as small tumors and present the clinical picture of a spreading ulcer. The diagnosis can only be made absolutely by microscopical examination. The prognosis in a skin cancer is less favorable than with sarcoma of the skin. Metastases are uncommon. The treatment of sarcoma and carcinoma consists in radical excision. Large losses of tissue should be covered in with skin-flaps.

ECHINOCOCCUS OF THE CHEST-WALL.

Echinococcus vesicles in the chest-wall are rare. They are usually found in the muscular structures.

The author excised an echinococcus cyst the size of a hen's egg from the right pectoral muscle. Exploratory puncture showed a clear fluid which contained the hooklets. Otto reports a case in which an echinococcus cyst developed between the chest-wall and the costal pleura and reached the surface along the inferior margin of the shoulder-blades. In this case the growth had been mistaken for a lipoma. The diagnosis was made on incising the growth. It was not possible to remove the echinococcus cyst immediately, although recovery took place after prolonged suppuration. The only case of primary echinococcus cyst of the sternum is that reported by Madelung.

Diagnosis.—The diagnosis of echinococcus cyst of the chest-wall is difficult and may be impossible. Aside from being confounded lipoma, as in [illegible] case, it may be mistaken for abscesses and tumors of other origin. Exploratory puncture does not always the desired information, because it is easy to overlook the hooklets the fluid. Some authors consider the presence of succinic acid in fluid characteristic of echinococcus.

Treatment.—The treatment consists in extensive incision and moving the contents as thoroughly as possible. Recovery may place when these indications cannot be perfectly met, although there usually prolonged suppuration.

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Treatment.—The treatment consists in extensive incision and removing the contents as thoroughly as possible. Recovery may take place when these indications cannot be perfectly met, although there is usually prolonged suppuration.

CHAPTER XIII.

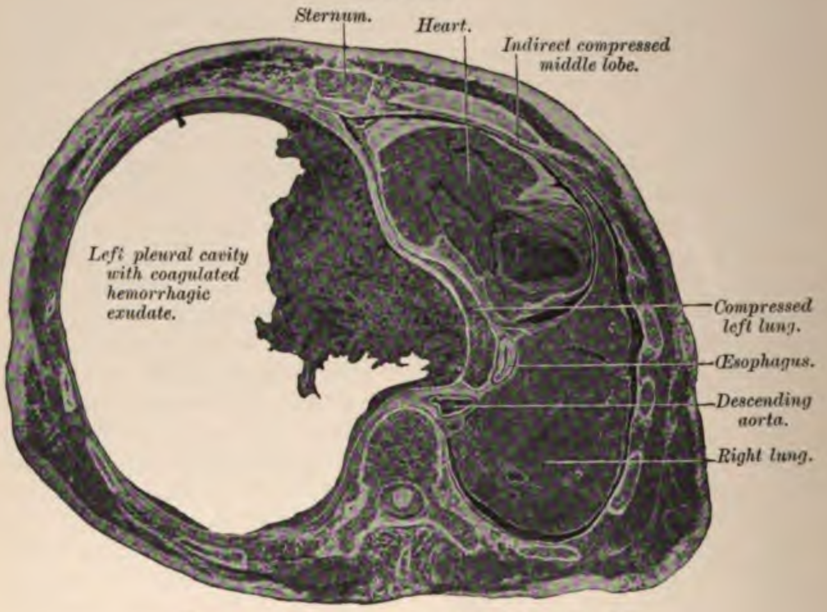
DISEASES OF THE PLEURA.

PATHOLOGICAL EFFUSIONS.

DISEASES of the pleura are primary in only a limited number of cases. In the vast majority of cases the conditions present are of secondary nature, either as part of the clinical picture of some general infection, or owing to extension of some local process in the neighborhood. The physiological conditions existent in the thoracic cavity are such that the diseases that develop here usually have an independent clinical picture. After recovery from some primary condition (for instance, inflammation of the lung) a characteristic pathological problem is presented in the pleural effusion. This demands special treatment independent of the primary cause. For this reason it is necessary to consider diseases of the pleura as independent affections. Effusions into the pleura and the tumors of the pleura are of especial surgical interest. The greatest variety of pathological effusions into the pleural cavity may be met with: transudates, clear serous exudates, cloudy serous exudates with all sorts of transitional stages to purulent foul exudates, serohemorrhagic fluid, and finally pure blood and chyle. Any effusion of fluid into the pleura of considerable extent produces a purely mechanical disturbance of breathing and of the circulation aside from the symptoms due to its intrinsic peculiarities. Therefore the symptoms common to all sorts of effusions will first be considered.

Mechanical Results of Pleural Effusion.—Pleural effusion of any extent develops at the expense of the physiological function of the neighboring organs. The conditions that necessarily arise are the result of limitation of space, because the power of the thorax to accommodate itself within physiological limits to limitation of this sort is comparatively slight. The changes produced by extensive effusions into the pleura will be considered in connection with the case depicted in Fig. 175. This represents the transverse section of the chest of a phthisical patient who suffered from left pleural effusion for about twelve years, and was comparatively comfortable while under observation during this time in the hospital. The section is made through the seventh dorsal vertebra. The changes are first of the chest-wall, then of the lung, then of the neighboring organs in the mediastinum, and finally of the abdominal organs. The left pleural cavity is occupied by an extensive serosanguinous exudate. The pleura has been altered to a dense fibrous membrane. The effusion has coagulated and forms a firm clot, a portion of which presented into the interior of the cavity. The left side of the chest is distended and was much larger than the right side. The sternum is pulled over to the left. The position of the left chest-wall is that of extreme inspiration—*i. e.*, the position it would occupy when increasing its volume to the utmost during respiration. The muscles have become atrophied, which can be recognized in the illustration. The left lung consists only of a bluish-black mass absolutely devoid of air. In ordinary cases the compressed lung adheres to the side of the vertebral column as a shrunken mass, provided it is not bound to the parietal pleura by adhesion. In this case it is crowded beyond the median line and lies in the right half of the thorax as a small half-moon-shaped mass close against the pleura.

Fig. 175.


Sternum.
Heart.
Indirect compressed middle lobe.
Left pleural cavity with coagulated hemorrhagic exudate.
Compressed left lung.
Œsophagus.
Descending aorta.
Right lung.

Transverse section through left-sided pleural exudate.

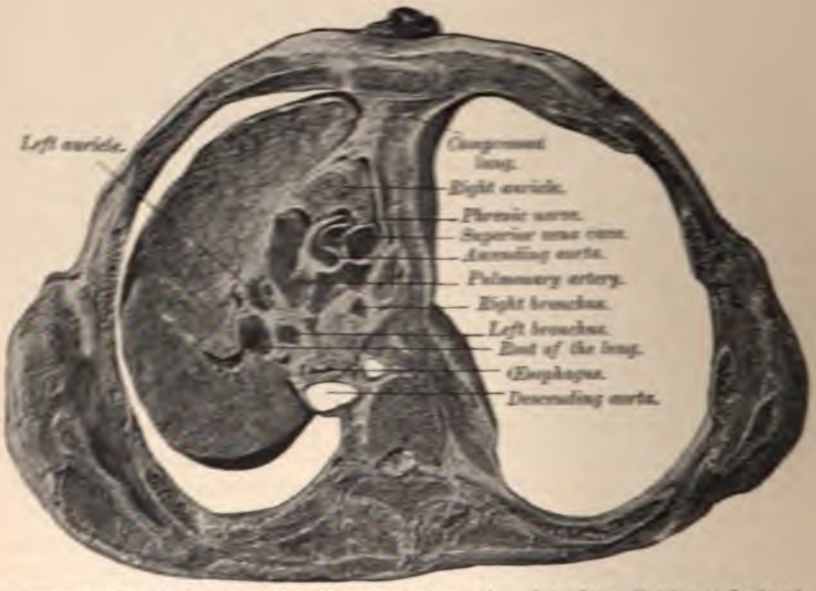
The mechanical conditions after atelectasis of the affected lung are rather complicated, and not to be explained by pressure of the exudate alone. (Rosenbach.) Manometric measurements of the intrathoracic pressure in pleurisy with effusion have shown that the pressure of the exudate is by no means the equivalent of the atmospheric pressure within the lungs. For this reason collapse of the lungs—that is, displacement of the air within the lungs—cannot be due solely in moderate exudates to the comparatively low pressure of the effusion. The following three factors should be taken into consideration with physiological respiration: 1, the atmospheric pressure acting upon the interior of the lung with the glottis open; 2, the pressure between the two layers of pleura; and 3, the elastic pressure of the lung-tissue.

The atmospheric pressure within the lungs tends to distend the latter. The elasticity of the lung and the pressure between the two pleuræ tend to diminish the size of the lungs. Normally there is no positive pressure upon the pleuræ, because the atmospheric pressure is supported by the thoracic wall, and the lung can only collapse to an extent allowed by the expiratory diminution in size of the chest cavity. Where there is fluid between the pleuræ, a certain amount of pressure is brought to bear upon the lungs, and the respiratory excursions of the lungs are distinctly interfered with, because the diaphragm is pushed downward by the exudate, and physiological inspiration cannot be accomplished. On the other hand, the diaphragm cannot follow the expiratory contraction of the lung, so that expiration is interfered with. To this is added the fact that the pleura is irritated by some inflammation which leads by reflex action to an expiratory position of rest, such as is observed even in dry pleurisy. All of these factors produce insufficient aëration, and atelectasis results, which is therefore explained by absorption of the lung with insufficient replacement, rather than by pressure. These conditions are present chiefly in the early stages of atelectasis. In the case depicted in Fig. 175 the conditions are permanent. The fibrous pleura is stiff and firm, the chest-wall and diaphragm are fixed, and the bronchi have long since become occluded. The respiratory factors no longer play any part, and there remains only a foreign body to deal with which can be considered from the standpoint of pressure.

The third factor to be considered is the displacement and pressure experienced by the neighboring organs. The heart is completely displaced to the right side and is pressed closely against the right anterior chest-wall. If the outline of the right lung is carefully followed, it will be seen that on account of the indirect pressure of the heart the middle lobe has been reduced to a small, narrow strip lying between the heart and chest-wall. The viscera in the mediastinum are also influenced. The œsophagus is pressed against the right root of the lung as a flat slit, and the descending aorta, which should lie to the left of the vertebral column, is on the right side of the heart. It is triangular in shape, at least in the cadaver. The diaphragm is concave downward seen from above, and the spleen and left kidney are depressed. Fig. 176 shows to what an extent the large arteries and veins may be compressed. It is evident that the aorta, the pulmonary vessels of the lung, and the superior cava are directly pressed upon by a right-sided effusion in this case and occupy a space much smaller than is normal.

It is evident that changes of this sort have a marked influence upon respiration and circulation. The compressed lung serves no function whatever, and the healthy lung is obliged to perform its work, which leads to marked dyspnœa. More work is thrown upon the heart owing to mechanical interference with its action and because the diseased lung acts as pathological resistance to the flow of blood. It is not strange that severe disturbances of circulation are a source of great danger to the patient, so much so that very slight causes, such as suddenly assuming the upright position, may be followed by immediate death. Any slight additional disturbance of the circulation may completely close the displaced vessels, temporarily perhaps. It may be that no blood can enter the heart, and secondarily the brain, on account of the additional pressure brought to bear on the inferior cava, or it may be that the large vessels arising from the heart are themselves compressed. It is evident that besides the disturbances in circulation and respiration there may be difficulty in swallowing, especially if one observes the compressed position of the œsophagus. These anatomical conditions explain a number of the clinical signs. With marked effusion there are dyspnœa, cyanosis, and a small and rapid pulse. The diseased half of the thorax is distended and shows no respiratory excursion. Percussion shows displacement of the heart; there is dulness, absence of respiratory signs, or vocal fremitus. When compression is not complete, there may be bronchial respiration. The minor points of these conditions belong to the sphere of internal medicine. When the effusion is fresh and of moderate extent, the lung is separated uniformly from the chest-wall if there are no old adhesions in the exudate. Fig. 175 shows this condition on the left side. The conditions present may be very complicated when there is an effusion and the lung is firmly attached to the thoracic wall.

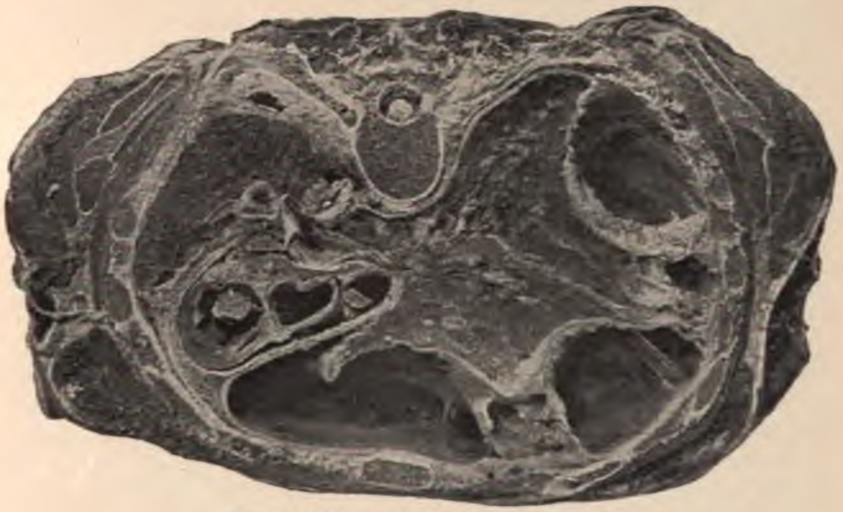
FIG. 178.



Compression of the large vessels and œsophagus by a pleural exudate. Section at the level of the sixth dorsal vertebra.

The preparation shown in Fig. 177 was taken from a phthisical patient who suffered from right-sided pyothorax, and who had been repeatedly operated upon for this condition. The results were relatively favorable. After recovery he had been discharged and followed his business as pedler for about two years, and then presented himself at the hospital with an effusion on the left side. The numerous adhesions prevented the formation of one large cavity but aided to form several smaller ones. Three of these are seen in the illustration. Exploratory puncture complicated the clinical picture, because one cavity contained serous fluid and the others a purulent effusion. It is quite evident that cases of this sort may offer difficulty, not only as regards the diagnosis, but also with reference to treatment. Finally there remain to be mentioned the symptoms that appear after an inflammatory effusion has existed for a long time, but has finally disappeared.

FIG. 177.



Pleuritic adhesions forming several cavities.

The older an effusion, the greater the inflammatory thickening and subsequent fibrous contraction of the pleura. After the exudate has become absorbed, a firm fibrous mass persists in the pleura which pulls the thoracic walls together by its contraction and diminishes the circumference. In the patient depicted in Fig. 177 the old empyema of the right side did not disappear spontaneously; the right side of the chest presents the condition just considered. There is thickening of the pleura, the lung is diminished in size, and the chest is contracted. In these cases the thoracic cavity becomes diminished so that the ribs close down upon each other and sink in. The vertebral column becomes bent, due to the contraction of one entire side of the chest with the concavity toward the diseased side. This condition produces, of course, interference with respiration.

Varieties of Pathological Exudates.

A division of effusions into the pleura, according to the nature of the contents, into inflammatory effusions, hydrothorax, hæmothorax, and chylothorax, is quite sufficient for all practical purposes.

The pathological causes of pleurisy with effusion are numerous. It may be a primary condition or secondary to some general infection of the body, as in a considerable number of the cases; or it may be due to infected material from some neighboring organs, particularly the lung. There is no infectious disease of the lung that might not be associated with pleurisy. Again, there are tumors of the lungs, inflammations of the mediastinum, carcinoma of the œsophagus, tuberculosis, pneumonia, influenza pneumonia, hemorrhagic infarct, cancer of the lung, abscess, gangrene, and diseases of the bronchial gland. Sometimes the pleura is infected from the abdominal cavity, as may be the case in subphrenic abscesses, suppuration following perforation of the stomach, abscesses of the liver, cholangitis, appendicitis, etc. The kind of pleurisy may vary considerably also. There may be dry pleurisy, pleurisy with effusion, and adhesive pleurisy. The clinical significance of pleurisy with effusion varies according to whether the effusion is serous or purulent. Even the bacteriological etiology, which would seem to be more accurate, is not sufficient in all cases, because many of the pleurisies are not of bacteriological origin; and, on the other hand, our knowledge is so incomplete that this method of distinguishing pleurisies cannot be employed. The variety of bacteria that may be found is extremely great. Pleurisies may develop in the course of any infectious disease, although the fluid may not present specific characteristics. The infectious diseases prepare the tissues just as in the case of heart disease, kidney or liver conditions. Nevertheless several distinct varieties can be distinguished, caused by tubercle bacilli, pneumococci, staphylococci, or streptococci, with or without saprophytic elements. The presence of these bacteria is of great importance as far as the course of the disease is concerned, and also in regard to the prognosis. The treatment will be greatly influenced by the kind of bacterium present.

Serothorax (Pleuritis Exudativa Serosa).—Most purulent effusions in the chest have probably passed through a serous stage—*i. e.*, the origin was primarily serous. They then show a comparatively large number of white blood-cells which causes the fluid to be more or less cloudy. Bacteriological examination shows micro-organisms, such as pneumococci, streptococci, etc. Purely serous effusions consist of a sterile light-yellow or clear fluid. There is usually considerable albumin. Only few cellular elements can be found, if any, and there are no micro-organisms. A purely serous effusion has little tendency to become purulent.

Etiology.—The etiology is usually difficult to determine. The modern view claims that as a rule there is tuberculous disease, either of the pleura itself or of the lung, which has given rise to secondary effusion, although with a primary serous effusion containing no micro-organisms one should always examine very carefully for tuberculosis. There are cases in which the primary cause must be sought elsewhere. E. Grawitz maintains that inhalation of carbon and dust particles produces sufficient irritation to cause pleurisy. These cases might be considered true primary pleurisy—*i. e.*, a disease developing without involvement of neighboring organs or without any constitutional conditions. "Catching cold" is of certain importance without doubt. Perhaps a pleura that ordinarily has sufficient power of resistance becomes susceptible to secondary influences on account of the disturbances in the circulation produced by the "cold." On the other hand, it may be that the pleura is already diseased, and that the cold is sufficient cause. A certain number of so-called idiopathic pleurisies develop in the course of joint-rheumatism. Fiedler's investigations seem to show that the disturbing elements supposed to cause acute articular rheumatism may attack the pleura without involving the joints.

Symptoms.—The symptoms of serous pleurisy are usually mild. There are signs of inflammation—localized pain, reflex disturbances of breathing, moderate fever, and slight constitutional signs—and symptoms due to intrathoracic pressure. The cases terminate favorably as a rule, but the final result depends, of course, on the severity of the individual case.

Treatment.—The treatment belongs to the realm of internal medicine: rest in bed, poultices, and salicylic acid in the rheumatic types.

The effusion may be removed in part or completely by aspiration. The indications for aspirating are as follows: 1. When the effusion is so large that it interferes with breathing and the heart action—*i. e.*, when marked cyanosis, dyspnœa, and rapid pulse are present. It must not be forgotten that any extensive effusion, reaching perhaps to the collar bone, may cause sudden death from heart failure or by compressing the large vessels even when there have been no previous signs of pressure. In any case in which the effusion is abundant it is imperative to remove a certain portion. 2. When the above indication is not present, the question will arise whether it is possible to influence favorably the disease or cure the condition by aspiration. Small effusions have so favorable a prognosis, even as far as function is concerned, that it will seldom be necessary to interfere. When the level of the fluid reaches to about the middle of the scapula, aspiration may be of value. One should, of course, consider the nature of the disease and the condition of the effusion. As soon as fever has disappeared, which indicates that the primary disease has become more or less inactive, the effusion will usually become absorbed with the aid of diuretics. When this does not take place a permanent cure may be obtained by aspiration. In cases in which fever persists for weeks, and the effusion does not become absorbed, but shows a tendency to increase, aspiration may be of value, because it removes an irritating foreign body containing fever-producing elements, and favors absorption and convalescence. The removal of the pressure of the exudate is of value in this connection. Sometimes this measure is of no avail, because aspiration may be simply a palliative measure which does not attack the cause and does not prevent reaccumulation of the fluid. Under certain conditions aspiration may be repeated after a certain lapse of time, perhaps with more favorable results. In any case no damage is done. The possibility of deriving no benefit should not lead one to desist from aspiration, and it should not be forgotten that it is the surgeon's task not only to heal, but also to heal quickly. In pleurisy especially, the rapidity with which recovery takes place may be of importance, because the danger of having conditions develop secondary to long-continued process is removed. The longer a pleurisy exists, the less the chance of complete recovery and the thicker and more dense the fibrous deposit remaining after recovery. Secondary conditions are more likely to develop, such as bronchiectasis and tuberculosis of the lungs, when the pleurisy is allowed to continue. When the pressure has persisted too long, the function of the lung may be permanently destroyed.

In very refractory cases, in which the effusion cannot be made to lessen by any means, and repeatedly accumulates, a radical operation has been recommended and performed with success. (Rosenbach.) Gläser made successful use of hydraulic drainage. Krause was obliged to perform Schede's thoracoplastic in a case of rheumatic serous pleurisy that persisted for years.

Serous effusions are of especial interest when produced by pneumococci or other pus organisms. As has been mentioned, the difference between purely serous pleurisy and pyothorax is simply a matter of degrée. Sometimes it will be found that only the upper layers of the effusion are serous, and that the lower consist of pure pus. In cases of this sort one should always be prepared for severe symptoms. As long as these signs do not appear, the same rules apply as in sterile effusions, because at times this form of effusion disappears spontaneously.

Pyothorax; Empyema.—When a pleural effusion has become purulent, it is spoken of as an empyema. The condition has been produced by invasion of the pleura by pus-producing organisms. Empyema does not present its characteristic signs at first, but develops in all probability from a serous effusion. There are all sorts of intervening stages between purely serous and purulent effusions. As a rule when suppuration has taken place the characteristics of the effusion are so marked that there can be no doubt as to its nature.

The pathological and bacteriological causes of empyema vary. It makes considerable difference whether streptococci or tubercle bacilli are responsible for the condition. Primary empyema proper occurs only when the pleura has been injured from without and is directly infected through the wound. In all other cases, even in those in which there is no evidence of disease in the neighboring organs or of constitutional disease, one must assume that the pleura has been secondarily involved by some virus circulating in the blood or in the lymphatics. In a certain number of cases the autopsy will show primary foci that were not detected during life. Generally empyema is secondary to some disease of the neighboring organs, usually of the lung. In spite of the great variety of symptoms, there are certain fundamental conditions connected with empyema, no matter what the origin, which will be considered first of all. The distinctive signs of the varieties of empyema will be given later.

Symptoms.—The symptoms of empyema are those due to the mechanical effects of the effusion already considered, and those associated with an abscess. Of the latter may be mentioned fever, which may be high and associated with chills. Fever due to suppuration and absorption of toxic material manifests itself in rapid decrease in weight and cachexia which is fatal within a comparatively short time if aid is not given. Sometimes metastatic abscesses form.

Empyema may heal, in two ways as the result of nature's efforts. The pus may become inspissated and absorbed. In place of the pus will be found a hard, friable, and partially calcified mass. This termination is not favorable, because the scar formation is great, and there is no certainty that the suppurating process will not be lighted up again. The other alternative is to have the pus break externally, when the pulmonary pleura may be ruptured and bronchi may be perforated. The pus will then be expectorated with violent attacks of coughing. This condition is not so unfavorable as might be supposed, but it is evident that the pus cannot be completely removed in this way, and that it is not desirable to have purulent material pass through the lungs. The conditions are relatively much more favorable when the empyema perforates the costal pleura and finds its way outward through the chest-wall. This is so-called empyema necessitatis.

Prognosis.—Generally recovery by natural means does not take place and the patient succumbs to long-continued suppuration. Even when relief does follow nature's efforts, this may be so tardy that interference is indicated even in cases in which the pus has ruptured into the bronchi. It is evident that the surgeon should never await such an event, but should always remove the pus as soon as he is sure that it is present. The remarks already made relative to the effect of pleural effusions in general apply, of course, in a much more marked degree to empyema. The longer this persists, the more the function of the lung is endangered, because its power of expanding is lost.

Treatment.—The fundamental rule in the treatment of empyema is to remove the pus as early and as thoroughly as possible, and to secure adequate drainage as long as the secretions persist. The results are most favorable. The fever diminishes almost immediately, and in a few days the patient's general condition improves.

The method in general use consists in thoracotomy with partial resection of one rib. This procedure secures complete removal of the pus and gives the best drainage. The conditions are favorable for restoration of the lung's function provided it is still capable of action. As a result of opening the pleural cavity acute pneumothorax develops, which persists for some time. This is, however, of minor significance, because the immediate effect of the entrance of air into the pleural cavity is comparatively slight. The inflamed pleura does not react so quickly to the irritation of this foreign body as does a healthy pleura, and the system has already adapted itself to a diminution in the breathing surface.

The method of expansion after operative pneumothorax is as follows: It has already been emphasized that the power of expansion of the lung suffers more the denser and more resisting the pleura. A second factor, which, according to Rosenbach, diminishes the power of expansion is obliteration of the pulmonary tonus, due to prolonged compression and inflammatory irritation. There is a relation, regulated by the vagus nerve, between the tonus of the lung and the expiratory and inspiratory movement of the chest. The lung contracts during expiration and expands during inspiration. In empyema the lung-tissue is subjected to the influence of a foreign intrapleural body and is in a state of maximal tonic contraction. The power of expansion depends on removal of this abnormal condition and restoration of the normal tonus. Loss of lung tonus, according to Rosenbach, is the reason why in old serous effusions the lung does not expand during forced aspiration. Provided that the lung is still capable of expanding, the conditions after opening the pleura will be as follows: If any lung-tissue remains capable of function, this will collapse similarly to the condition found at autopsy. In expiration, and especially during attacks of coughing, there will be an increase in pressure in the interior of the communicating lung cavity. This tends to distend the collapsed lung, which will retain the air contained, because of the persistence of the increased pressure during expiration, that distended the lung at first. During inspiration it would prevent collapse of the lung, because it acts in unison with the general tendency of the lung tonus. When the pulmonary pleura touches the costal pleura in any place, it will become adherent and the lung will become fixed in its expanded position. In favorable cases of empyema operated upon early, the lung will expand within a very few days. Schede saw a healthy lung expand completely within twenty-four hours after resection of the chest-wall for a malignant tumor. One should never forget that the power of expansion is modified, and should endeavor to assist expansion by any artificial means possible. This subject will be considered later.

Another method of operating upon empyema is by simple thoracotomy, which consists in making an incision in the intercostal space without resection of the rib. This method is frequently used, and is quite sufficient in many cases. It may happen, however, that the opening becomes closed because the ribs approximate each other, which interferes with drainage and may make subsequent resection of the rib necessary. This operation may be done with ethyl chloride or

Schleich's mixture, which is an advantage in cases in which the danger of general anæsthesia is great. If, however, a general anæsthetic is used and resection of a rib is not counterindicated, the author considers that this is much more advisable, especially as it is not associated with unfavorable after-effects.

It is evident that simple emptying of the pus of an abscess does not insure a cure, provided that drainage is subsequently insufficient. This is the reason why the puncture method made use of in serous effusions does not apply to purulent effusions. The only puncture method which possesses value is the hydraulic drainage of Bülau. A permanent outflow to the pus is furnished and negative pressure produced in the chest. The advantages claimed for this method are that the operation may be done easily and without anæsthesia and through a very small wound, and that artificial pneumothorax is avoided. On the contrary, a negative pressure is produced in the pleural cavity by suction upon the fluid, which thus favors expansion of the lung. The idea upon which this method is based is perfectly rational, and the results have been quite favorable in certain cases. The great disadvantage is the uncertainty of its effectiveness. In some cases the power of expansion of the lung is so lessened that it is not possible to remove all the pus, because it drains off only in quantities corresponding to the space which can be filled by the expanding lung-tissue. Besides, the drainage-tube may become plugged with coagula of fibrin, which interferes materially with the success of the operation. In cases of this sort resection of the rib becomes necessary, and it is evident that on account of the delay patients are at a disadvantage as far as complete recovery is concerned.

When the lung is capable of full expansion, the result is very favorable after resection, especially as hydraulic drainage with all its advantages can be made use of, as will be seen later. Other things being equal, the author considers that thoracotomy with resection of a rib is the normal method of procedure, and recommends Bülau's method of drainage only in cases in which it is not permissible to use a general anæsthetic. On account of the great weakness of the patient, the first endeavor will be to remove the immediate danger to life. With bilateral empyema hydraulic drainage should be tried, because it is extremely dangerous to allow bilateral pneumothorax to develop.

Varieties of Empyema.—METAPNEUMONIC EMPYEMA.—Almost every case of croupous pneumonia develops some secondary infection of the pleura with pneumococci provided the pneumonia is not central. As a rule this pleuritis disappears with the process in the lung, and often does not amount to anything more than a fibrinous or serofibrinous deposit. In rare cases the condition in the pleura may go on to suppuration during the pneumonia; but as a rule evidences of suppuration do not appear for several days after the crisis. Sometimes pneumococcic empyema develops without preliminary inflammation of the lung, simply in the course of pneumococcic sepsis. These bacteria may be found in pure cultures in the pus. At times, however, staphylococci and streptococci are present.

A large percentage of empyemas in children are of pneumococcic origin. The condition in children does not differ materially from that in adults. The signs of suppuration are especially marked, as is usual with infections in children, which is no reason for interpreting the symptoms differently than in adults.

Prognosis.—Pneumococcic empyema pure and simple has a favorable prognosis, which is explained by the comparatively slight virulence and slight resistance of this bacterium. Spontaneous recovery has been reported with small effusions. The author followed a case of bilateral empyema on one side of which a radical operation had been done. As soon as the corresponding lung had been restored to function it was planned to attack the small empyema of the other side. This had, however, disappeared entirely. As a rule one should not wait for spontaneous recovery because in the vast majority of cases this will do damage. When there is any reason for waiting, one should always determine accurately whether the effusion increases, and the general condition of the patient should be carefully watched.

Treatment.—The author knows no reason for modifying the treatment in children, and always resects a rib. On account of the elasticity of the chest-wall in children recovery takes place much more quickly than in adults. In numerous cases of empyema in children in which the author has resected ribs he has had no fatal results. In several cases in which suction drainage was used he was obliged to resect ribs subsequently because the first method was inadequate.

STAPHYLOCOCCIC AND STREPTOCOCCIC EMPYEMA.—This condition is primary in the proper sense of the word when the organisms are brought in direct contact with the pleura through some penetrating wound of the chest-wall. Empyema of this sort is termed idiopathic when the bacteria in question that are present in the circulation produce local effects in the pleura without causing disturbance in other organs. This process corresponds to osteomyelitis. The pleura is especially apt to become infected by staphylococci and streptococci in a number of infectious diseases. In some cases a primary focus will be found on autopsy that had escaped clinical observation. Empyemas of this sort frequently owe their origin to septic processes in the lung or in neighboring viscera (subphrenic abscess). Streptococcic and staphylococcic empyema are very toxic and should be operated upon as soon as possible.

PUTRID EMPYEMA.—This condition develops when a serothorax or pyothorax becomes secondarily infected by putrefactive organisms, usually on account of direct communication with some neighboring focus (gangrene of the lung, bronchiectasis, perforating carcinoma of the œsophagus, carcinoma of the stomach or intestines, etc.). Not infrequently no communication can be made out. An empyema that has been operated upon may become infected and the secretion undergo putrefactive changes if care is not exercised in the treatment.

The offensive discolored exudate contains a great variety of putrefactive organisms. In rare cases in which no bacteria can be found, it is assumed that the odor is imparted to the exudate in the same way as in the case of intra-abdominal abscesses in which the intestine is intact. Putrid empyema is followed by extreme prostration within a short time on account of the absorption of decomposing material, and the prognosis is, generally speaking, unfavorable.

TUBERCULOUS EMPYEMA.—This condition varies from other forms of empyema, and must be specially considered. Tuberculosis of the pleura manifests itself in a variety of ways. As already mentioned, a large percentage of serous pleurisies are produced by tuberculosis, so that the presence of a pleurisy is always suspicious of some latent tuberculosis. In individual cases the effusion may be produced by the irritation of some focus situated near the periphery of the lung. As a rule, however, there will be straight tuberculosis of the pleura, usually near the apex of the lung. Autopsies frequently show adhesions between the pleuræ in this region which are evidence of old tuberculosis of these membranes. Sometimes cheesy masses are found between the adherent membranes.

Tuberculosis of the pleura develops in the course of disease of some neighboring organs (lungs, vertebral column, ribs) or is part of a general miliary tuberculosis, and is primary in only a few cases. In the latter instance the pleura is covered with tubercles and a fibrinous pseudomembrane develops which may be detached along with the tubercles. This pseudomembrane always shows abundant new-formed bloodvessels in the immediate vicinity of the tubercles and hemorrhages are almost always present. For this reason the effusion is usually hemorrhagic.

Although hemorrhagic effusions into the pleura have been observed in other diseases (dyscrasia, hemorrhagic diathesis, alcoholism), this condition is usually indicative of tuberculosis or malignant disease. A serosanguinous effusion must not be confounded, of course, with a hemorrhage into the pleural cavity. Tubercle bacilli are not easy to find in the serous or hemorrhagic fluid, and bacteriological proof is best found by animal experiments. It may even be impossible to obtain this evidence. The tubercle bacilli may sometimes be found in the purulent effusion which develops in the course of tuberculosis. This purulent condition appears as a rule when an abscess of the lung has ruptured, and is associated not infrequently with pneumothorax. When the pus is examined with the ordinary methods it will be found sterile. In other cases there is a mixed infection, similar to that which takes place in the tuberculous foci of bones. Finally, the surgeon may have to deal with an ordinary empyema that develops in a tuberculous individual. In these cases the tuberculosis is only a predisposing cause to the effusion, just as is the case with other infectious diseases.

Treatment.—As far as treatment is concerned, primary serous effusion should be treated according to the rules already laid down, and aspiration repeated if necessary. Some authors claim that thoracotomy is indicated when aspiration has been repeatedly unsuccessful. This is, however, rather risky when the primary cause is tuberculosis, because recovery may not follow. Serosanguinous exudates should always be treated by palliative puncture. It is not to be expected that the success will be great, because the primary cause persists, and aspiration should be done because the subjective signs demand it. An example is the patient depicted in Fig. 175. In this case the effusion was not removed and he remained comparatively well for twelve years. It seems to the author questionable whether the result of treatment would have been as good if he had been aspirated repeatedly.

The question of operative interference is extremely difficult to answer in tuberculous empyema. If there is present an idiopathic empyema in a tuberculous individual, the same rules apply as to empyema in general, and a radical operation should be performed. Palliative measures are indicated in a case of this sort just as in empyema in general, when the general condition of the patient counterindicates operative interference. The situation is different in tuberculous empyema proper, which is frequently associated with pneumothorax. The surgeon cannot hope recovery to follow a radical operation, and must always expect a permanent sinus. When this happens, the patient is worse off than with an unopened sterile empyema, because of the conditions that subsequently develop in a chronic suppurating process (amyloid degeneration). Cases are numerous in which the results of radical operation have been very favorable. Generally speaking, it is well to confine one's self to palliative measures in severe cases, and to operate only when the general condition of the patient is in favor of a permanent result. Injections of iodoform glycerin may be tried.

Hydrothorax.—Hydrothorax develops in the course of some general circulatory disturbance, chiefly in connection with cardiac insufficiency and nephritis; but may develop in connection with cachexia and in the agony of death. The effusion is usually to be found in both chests at the same time, contrary to what is seen in inflammatory effusions. It develops on one side only when an effusion is prevented by adhesions. The fluid is usually quite dark, and contains less albumin than a serous exudate (3 per cent.) and has a correspondingly low specific gravity (1018 at the highest).

Treatment.—The treatment will be directed toward the primary disease. Surgical interference will become necessary when the mechanical effects of the effusion are so great as to become alarming.

Hæmothorax.—This condition is produced by some penetrating wound or blunt force that ruptures vessels of considerable size, or when some vessel in the pleural cavity is opened by erosion of its wall (aneurisms of the aorta, tuberculous cavities of the lung, caries of the ribs, etc.).

Symptoms.—The symptoms of hæmothorax are alarming. Besides the signs of pleural effusion and irritation of the pleura, there will be symptoms of internal hemorrhage, such as pallor, cold perspiration, collapse, weak and rapid pulse, unconsciousness, delirium, etc.

Treatment.—The treatment will rarely remove the cause of hemorrhage, and will generally be confined to symptomatic measures. The patient should be kept as quiet as possible and the internal hemorrhage combated by intravenous injections. The author considers that the danger of exciting hemorrhage on account of increased heart action is slight compared with the striking immediate advantage that a collapsed and exsanguinated patient derives from intravenous infusion. Personally he uses 1500 to 3000 c.c. salt solution.

The fact that the blood poured into the pleural cavity is subjected to a moderate amount of pressure favors recovery, although the continual respiratory movement is a disadvantage. Frequent attacks of coughing may be disastrous, and it is well to suppress this symptom as much as possible with narcotics (codeine, morphine). When the danger of immediate hemorrhage is passed, the absorption of blood should be accurately controlled. The chief danger consists in infection and suppuration of the blood-clot. When suppuration is shown to be present by exploratory puncture, the ordinary treatment for empyema should be instituted. Prolonged fever is no criterion, because this may be present during absorption of the blood. Sometimes absorption occupies considerable time. In a case which the author had an opportunity to observe, the exudate increased at the end of the first week without any fresh hemorrhage. In all probability there was an effusion into the pleura produced by the irritation of the blood, just as chronic arthritis usually follows hemorrhages into the large joints. If absorption is delayed, one may have to resort to aspiration, although this should never be done until one is perfectly certain that the vessel from which the bleeding arose is definitely plugged.

Chylothorax.—Chylothorax develops when the thoracic duct has been injured within the chest. The number of cases reported is about 40. About one-third of these were produced by trauma. In the majority of the cases the duct has been opened directly in connection with fractures of the spine. The rest of the cases develop in connection with intrathoracic tumors (carcinoma of the pleura and of the lymph-glands near the opening of the duct).

Diagnosis.—The diagnosis is made by exploratory puncture. Chyle is a cream-like fluid of low specific gravity. Chemical examination shows the presence of sugar, and microscopically lymphocytes and minute droplets of fat are to be found. Chylothorax must not be confounded with so-called chyloid effusions into the pleura, which are found especially in connection with carcinoma and tuberculosis. The admixture of fat and degenerated leucocytes or cells from the tumor give the exudate a milky appearance, so that it resembles true chyle very closely. If this milky effusion is found shortly after an injury, the diagnosis is easy, although at times it may be very difficult to distinguish the conditions. The presence of sugar is of some value, because chyle usually contains a considerable quantity, whereas the chyloid fluid contains only traces. There is also a difference in the consistence of the fluid. Pure chyle is more like cream, whereas the chyloid fluid resembles skimmed milk.

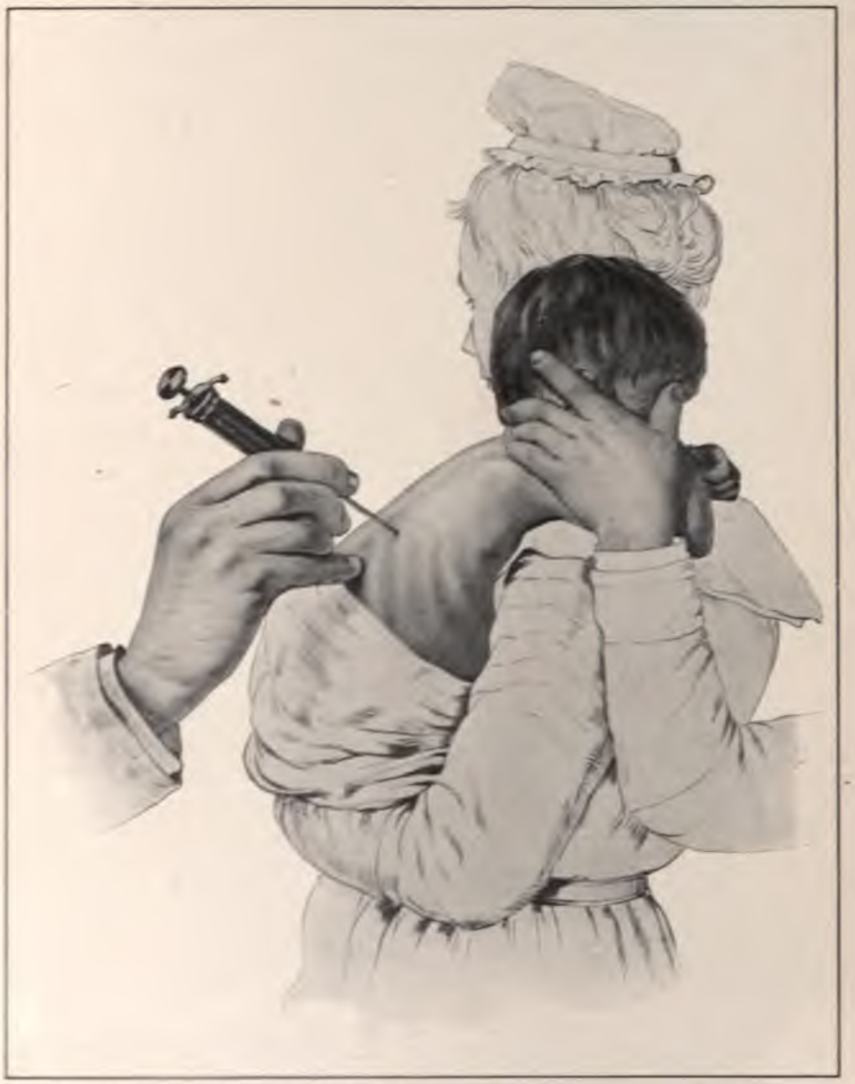
Prognosis.—The cases observed have shown that recovery may take place without interference. It is supposed that the wound in the duct heals or that anastomoses develop. The prognosis, however, is bad in the majority of cases on account of the incidental conditions. The pressure of the effusion favors recovery, as in the case of hemorrhage into the pleura, and for this reason there is no indication to interfere. Only when the fluid gives rise to severe symptoms of pressure should one undertake aspiration, and if necessary repeat this step. Recovery has followed repeated and frequent puncture.

Operations for Pleural Effusions.

Exploratory Puncture.—This method of examination may be of the utmost importance for the diagnosis, because the surgeon is at times in no other way able to make any accurate statement regarding the presence or the nature of an effusion. It should be made use of in all cases in which the treatment will depend upon the results of a puncture. With proper asepsis there is practically no danger. Even when the internal organs suffer injury, no serious results follow if care has been taken to move the canula only in one direction. Lateral motion may, of course, lacerate the tissue. An ordinary subcutaneous syringe is quite sufficient, although it may be necessary to use a needle about 6 cm. long instead of the ordinary variety. The aspirated fluid should always be placed upon a slide immediately and examined under the microscope. Sometimes it is advisable to stain the effusion with fuchsin or methylene-blue, so as to obtain some idea as to the bacteriology of the exudate. A culture should be made and the syringe carefully sterilized after having been used.

Paracentesis.—The chest cavity is aspirated for the purpose of diminishing or removing completely some pathological contents. The author considers that the simplest apparatus is always best, and uses a trocar of medium size, to which a rubber tube can be attached. Both should be sterilized before using. This trocar is introduced between the ribs over the effusion, or, provided there is no especial choice, between the fifth and sixth rib. Although the pain of this operation is not great, a local anæsthetic is always indicated because it tends to reassure the patient. It sometimes facilitates the introduction of the trocar to make a small preliminary incision in the skin. After removing the stilet a rubber tube is attached and the fluid allowed to flow into a vessel containing an antiseptic solution. The rubber tube attached to the canula and the lower end of which is beneath the level of the solution, serves the double purpose of preventing the entrance of air into the chest cavity and exerts a certain amount of suction on account of the weight of the fluid contained in the tube. Entrance of air into the pleural cavity may be prevented by placing a rubber condom over the external opening of the trocar. After

PLATE XIII.



Showing the Method of Making an Exploratory Puncture for Fluid in the Pleural Cavity in an Infant. (Koplik.)

removing the stilet this is allowed to hang down over the opening, and will close the space when the pressure in the interior of the pleural cavity becomes negative during inspiration.

The author has always been successful with these simple measures and does not recommend forced aspiration. One punctures the chest only in case of sterile exudate, and it is immaterial whether the exudate is wholly removed or not, because the object is to relieve the excess of pressure and favor absorption of the remaining fluid. There are exudates, however, especially those of long standing, which are under negative pressure and do not drain off except when force is used. Too forcible aspiration should be avoided, because it may cause hemorrhages into the pleura and other annoying accidents, such as œdema of the lung, etc. The utility of forced aspiration is questionable, and it should not be used as a matter of routine, as is so frequently done. Violent coughing is not uncommon during aspiration, an accident which is of no particular importance, and can be met by injections of morphine. The disturbance of the circulation is much more alarming, and occurs on account of the sudden change in the intrathoracic pressure. The patients become cyanotic, the pulse rapid and irregular, and unconsciousness and collapse may follow. The pulse and general condition of the patient should be carefully watched. Stimulants should be given at the time of aspiration and the fluid should not be allowed to drain off too rapidly. Fifteen minutes or more should be occupied with this part of the operation, and it is not well to remove too much fluid at one time. There are no absolute guides as to the amount of fluid it is permissible to remove, but it is advisable not to remove more than two quarts at a time, and to repeat the operation if necessary.

Paracentesis with Suction Drainage.—For this purpose a trocar of large diameter, a catheter, and a stopcock are necessary. The catheter should be of such a calibre that it just fits into the trocar. About 3 feet of rubber tubing is necessary, with a glass tube at one end, which can be attached to the catheter. At the other end there should be a weight, either a piece of lead or a glass funnel. It is also necessary to have a vessel of considerable size, in the bottom of which is some antiseptic fluid. The trocar is introduced into the chest. After removing the stilet the catheter is pushed through the trocar into the pleural cavity. The catheter should be closed by the stopcock before introducing and the trocar carefully removed. The catheter is kept in place by strips of adhesive plaster or by silk sutures, and is connected with the rubber tube, the distal end of which is beneath the level of the fluid in the vessel containing the antiseptic. The stopcock on the catheter is opened and the contents of the pleural cavity are emptied into the vessel. The apparatus should be carefully watched, for, as already mentioned, it does not always work smoothly. When the catheter becomes plugged with pieces of fibrin, these may sometimes be removed by forcing fluid back into the chest. The level of the effusion should be determined, because the amount that flows out corresponds to the expansion of the lungs. When the lung has lost its power of expansion the amount of fluid will be too small, and one should not delay a radical operation.

Thoracotomy.—This consists in opening the pleural cavity in an intercostal space. In the succeeding paragraphs will be considered which intercostal space is to be chosen. If a general anæsthetic is not to be used, some local anæsthetic may be applied. After infiltrating the skin the underlying tissues are injected and divided layer by layer. The subsequent treatment is the same as after resection of ribs.

Thoracotomy with Resection of Ribs.—Systematic partial resection of ribs was first recommended by Roser, and became a recognized method of treatment for empyema since König's work.

The advantages of this method are evident. By removing a piece of bone free access is given to the abscess cavity, and it is possible to explore and mechanically clean the cavity thoroughly. At the same time the conditions for drainage are the best possible. This operation can be done very quickly, and the author considers it the normal method of procedure.

When the conditions present demand resection of a certain rib, one has the choice of two methods. Schede recommends making an incision along the lowest point of an abscess cavity so that the pus can flow out without obstruction when the patient is recumbent. He resects the ninth or tenth rib externally to the long muscles of the back. The advantage of this method, as far as drainage is concerned, is evident. It has, however, been claimed that this drainage may be defective on account of the diaphragm rising and interfering with the exit of fluid by compressing the drainage-tube and granulations plugging the opening. An attempt has been made to avoid this condition by resecting the fifth or sixth rib in the anterior or midaxillary line. The pus cannot at first be completely removed with this method, and the patient must be put in certain positions daily for this purpose, which is a distinct disadvantage (König) (side position lifting the pelvis, etc.). The author prefers the point in the back lowest down, but leaves it to the individual surgeon which position he considers best, as good results are to be obtained after an operation in either region. It is unjustifiable to resect several ribs at first as long as there is doubt as to the power of expansion of the lung.

When an empyema is encapsulated, the position of the pus will, of course, indicate the line of incision. In cases of empyema that have ruptured where there is not sufficient exit for the pus, a rib may be resected at the seat of rupture if this position is favorable. When the sinus is too high up and does not afford sufficient drainage, there is no reason whatever for allowing the seat of rupture to influence the surgeon in his choice of the rib to be resected. In a case of this sort the fistula above will heal provided that recovery follows the operation.

As far as the anæsthetic is concerned, the surgeon is confronted with the old problem: ether damages the lungs more and chloroform does more harm to the heart. Generally speaking, chloroform should be preferred because especial care must be given to the lung. Local anæsthesia may render the operation much easier, but does not avoid pain while resecting the rib. The author uses Schleich's method only when chloroform anæsthesia is distinctly counterindicated on account of cardiac weakness or depraved general condition, or when the patient prefers to undergo a certain amount of inconvenience rather than risk general anæsthesia. With intelligent people the author has repeatedly done this operation under primary anæsthesia. The danger of sudsequent bronchitis is slight if ether is used.

The technic of the operation is as follows: a skin-incision is made 8 to 10 cm. long down to the rib to be resected. The hemorrhage usually ceases spontaneously. The periosteum is divided along the line of incision and separated above and below with an elevator. A bent periosteal elevator is placed between the periosteum and the posterior wall. Sometimes it is necessary to divide the insertion of the intercostal muscles with a knife. The periosteal elevator is left beneath the rib and the bone divided alongside with bone-forceps or with Gigli's saw. The rib is lifted out and about 6 cm. removed. The intercostal artery covered by the lower margin of the rib should not be injured; if it has been injured, it is difficult to tie before resecting the rib. One should not waste time in trying to catch the vessel, but complete the resection as rapidly as possible. If operating with Schleich's anæsthesia, care should be taken not to injure the intercostal nerves.

Up to the present the pleura has not been opened. It is much thicker than normal and may easily escape injury. It should be incised with a knife sufficiently to allow the entrance of one finger. The pus flows out more freely during expiration than during inspiration. The finger in the pleural cavity prevents too rapid emptying of the abscess cavity.

After the greater part of the pus has been removed, the wound in the pleura is enlarged laterally and any fibrin in the cavity cleaned out. Special attention should be given to this point because it surely favors rapid recovery. If it is impossible to do this at this time of operation, it should not be done later, because it delays convalescence. All large coagula should be removed with a sweep and the pleural cavity washed out if necessary. The only purpose this serves is the removal of masses of fibrin. No more bactericidal action is expected than in the case of other suppurating wounds. The fluid used should be at the temperature of the body, so as to avoid irritation. After cleaning out the pleural cavity, rubber drains the size of the thumb, or even two side by side, should be introduced into the cavity. A safety-pin should be passed through these or they should be sewn to the skin with silk, so as to prevent falling into the empyema cavity. The drainage-tube need only be sufficiently long to reach the abscess cavity. When they are longer they are not only not of value, but may also do harm, because they lie between the lung and the costal pleura and prevent union between the two membranes. The wound in the chest-wall is packed with iodoform gauze and a firm dressing applied.

The following points should be observed in the after-treatment:

1. General medical treatment and diet: light easily digested food and daily movement of the bowels. Bronchitis and other conditions of the lung should be treated with expectorants. Coughing may favor expansion of the collapsed lung and should not be too much restricted by sedatives.

2. Treatment of the wound: the dressing should be changed whenever it is saturated with secretion. When the wound is at the level of the fifth and sixth ribs, one should place the patient in such a position while changing his dressing that the wound is the lowest point in the cavity so that the fluid will run out as freely as possible. The author does not wash out the cavity, because reflex collapse has followed on account of the irritation to the pleura and the adhesions between the two pleura may be broken up.

3. Restoration of the collapsed lung is the chief aim of treatment. It has been mentioned that coughing and forced expiration by increasing the pressure in the bronchial tubes tends to distend the lung. As soon as the patient has recovered more or less forced expiratory motions are recommended; for instance, he is told to blow up an air-cushion several times daily. When the opening in the pleural cavity is smaller than the diameter of the main bronchus, the diseased lung will again take part in normal respiration. The air will enter the lung during inspiration through the main bronchus with greater ease than through the opening in the chest-wall, so that the collapsed lung is obliged to distend during inspiration.

Thiersch constructed a valve-like bandage. He closes the opening in the chest-wall with a thin piece of rubber; a piece of drainage-tube passes through the centre of this and communicates on the inside with a collapsable piece of tubing. This allows the air to escape from the pleural cavity, but prevents its entrance. Roehelt used a similar apparatus; and Schede achieves the same result by covering the opening with a thin layer of oiled silk.

Appliances that diminish the air-pressure in the pleural cavity aid expansion of the lung most. The wound must be covered with an air-tight bandage, and in the interior of the drainage-tube the pressure must be negative. Perthe's apparatus seems to be valuable in this respect, for even old cases have expanded after using it. The wound is covered with a sort of valve, perforated by a piece of rubber tubing, and the opening into the pleural cavity is closed air-tight by means of a circular air-cushion. The valve is held close to the chest-wall by straps. Negative pressure is produced by means of a water faucet. The air is sucked out of the pleural cavity by means of the flowing water. A vessel is interposed between these two parts, and a U-shaped mercury manometer is so adjusted that the lowering of the intrathoracic pressure can be accurately determined. At a certain point air will enter the vessel from without and regulate the negative pressure immediately. The negative pressure made use of by Perthes varies between 30 and 130 mm. of mercury.

The temperature should be carefully watched during convalescence, and any rise interpreted as due to insufficient drainage. The position of the lung should be determined by percussion and auscultation when the dressings are changed. The drainage-tube should be shortened as rapidly as possible, so as not to interfere with the processes of repair within the pleural cavity. When the lung reaches the level of the wound, the tube should be removed and the incision packed with iodoform gauze. The wound should heal from the bottom, and when a patient no longer has fever and the general condition is favorable, he should be allowed to leave his bed.

Operations upon Old Empyemas (Pneumothorax, after Operations for Empyema).—The number of empyemas that do not recover completely when treated in the above manner is small, compared with the number of cases that heal. A large percentage of the first class are of tuberculous origin, because the tuberculous pleura shows little tendency to heal and usually there is tuberculosis of the lung at the same time. In addition, many cases, not of tuberculous origin, have not had the advantages of proper treatment in the acute stages. In Hamburg extensive empyema is frequently found in sailors of sailing vessels who have been for months without medical aid. Besides, certain conditions, such as emphysema or incidental diseases of the lung, interfere with recovery. When it is not possible for the collapsed lung to expand sufficiently to come in contact with the costal pleura, a secreting cavity remains between the layers of pleura and the wound shows no tendency to heal. Nature will diminish the size of this cavity to a certain extent, but when all has been done that is possible in this direction artificial aid must be resorted to. The visceral pleura and costal pleura become more and more thickened and resistant on account of the continued inflammation. Dense masses of fibrous tissue form and the ribs of the affected side are drawn closer together until they almost touch. This fibrous contraction produces changes in the vertebral column and chest-wall, causing curvatures with the concavity toward the diseased side. The function of the lung may be permanently interfered with. Besides, there is a continual discharge, and when the cavity is of any size there follow progressive loss of strength, amyloid degeneration of the internal organs, and finally death.

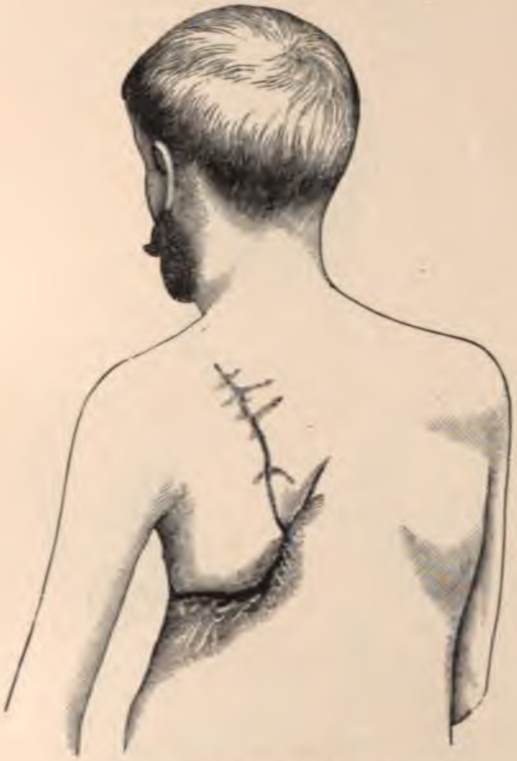
The severity of the symptoms and the chances of recovery following operation depend largely upon the size of the cavity. For this reason it is important to ascertain as accurately as possible the exact size of the cavity. This information may be obtained by combining various methods of examination. The percussion-note is low and tympanitic over the cavity, and there is absence of respiratory murmur. A probe will give the required information if there are no complications. A useful index is the amount of fluid that the cavity may hold. The author has used the Röntgen rays with success. The empyema cavity is filled with iodoform glycerin and then a plate is taken. The iodoform produces a deep shadow indicating the extent of the cavity.

Simon-Küster's Operation.—In this operation, as modified by Estlander, the ribs are resected subperiosteally over the entire cavity. As a rule an incision is made in one intercostal space and then the neighboring ribs resected above and below, each for about 8 cm. The number of ribs resected varies according to the size of the cavity. It is important to be radical, and to resect one rib too many rather than one too few, because if a dead space remains in the upper part of the cavity the result of the operation will be uncertain. A suppurating cavity remains which may communicate with the external wound or give rise to a retention abscess, so that a second operation becomes necessary. When the thoracic wall has been sufficiently immobilized, it adheres to the pulmonary pleura, suppuration ceases, and the fistula closes. After the sinus heals the function of the lung improves considerably. It takes part in respiration and expands again. In children, ribs that have been resected subperiosteally may be replaced almost completely. The incision recommended for this operation varies. A simple vertical incision, or an inverted T, or a V-shaped incision, or an L-shaped one has been made use of. Wagner, Saubottin, Beck, Quénu, and Tietze have modified this operation. These authors resect small portions of the ribs through two parallel and vertical incisions over the region of the cavity. The entire interposed portion of the thorax becomes movable and can be pressed against the lung. Jaboulay and Leymarie divided the sternal attachment of the first to the seventh rib; and Boiffin recommends resection of the ribs close to the vertebral column, making use, as it were, of the mobility of the costal cartilage.

Schede's Operation.—Schede observed that some empyema cavities did not heal in spite of extensive resection of ribs. The thickened pleuræ did not unite with each other and directly impeded recovery. He exposes the cavity throughout its entire extent and removes the fibrous tissue with the ribs. Schede's description of the operation is as follows: The incision is carried along the external margin of the pectoralis major from about the fourth rib downward to the tenth rib in the posterior axillary line, or to the lowest point of the pleural cavity. The muscle may be incised if necessary. The line of incision is then carried upward to the median line of the scapula, which must be kept as much as possible out of the way by pulling the arm forward. The incision is carried down onto the ribs, and the skin and scapula, with the subscapular muscle, are dissected up. All of the ribs which cover the cavity are now resected subperiosteally, if required, throughout their entire length.

With large empyemas it is usually necessary to resect the ninth or even the tenth rib up to the second inclusive from the cartilage back to the tubercle. This operation must be done subperiosteally, so as to avoid hemorrhage. The ribs are exposed posteriorly about to the angle, and then divided in the middle with bone-forceps and the fragments broken off one after the other with the hand, the anterior at the costal junction and the posterior close to the vertebral end. The posterior line of fracture will almost always be exactly at the tubercle. Cooper's scissors are now inserted through the old sinus and the thick masses of fibrous tissue, which may be 4 cm. in diameter, are divided along with the intercostal tissue close to the margin of the lung. Hemorrhage is controlled by an assistant compressing the intercostal arteries before they are divided. They are then tied immediately. It is by no means necessary to complete the operation at one sitting. If the patient is very weak, it may be considered sufficient to resect two or three ribs at a time and divide the corresponding soft parts, and postpone the rest of the operation until the patient has improved. Death from collapse will be avoided in this way. The cavity in the chest, which is like a shallow trough, must be covered accurately with the flap of soft tissue. The wound should be left open behind and the cavity packed with as little iodoform gauze as possible. Special attention should be paid to this point, and the patient watched closely during the days immediately following its use. The greatest diffi-

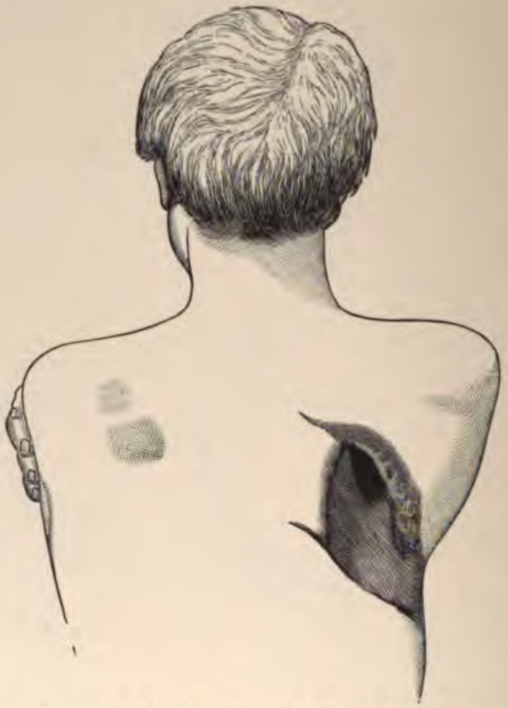
FIG. 178.



Incision for resection of thorax.

culty will be met at the upper portion of the pleural cavity, which is the only region that cannot be completely exposed in this operation, and therefore cannot be packed as a rule. A sinus leading to this region remains, which heals slowly, but as a rule closes in the course of time. Recovery is not rapid, because the fibrous pulmonary pleura does not adhere readily to the surrounding tissue. When a portion remains uncovered, there may be great difficulty in making this heal later. Sometimes it may be necessary to resect the first rib, because suppuration continues in the vault of the pleural cavity. Fig. 178 illustrates this operation. This patient had an extensive tuberculous empyema. A U-shaped flap had been made at some former operation and a portion of the scapula resected. The position of the second operation is indicated by the new scar-tissue. The results of this operation are excellent. Recovery has followed in cases that seemed almost hopeless, where there was pneumothorax of the entire side of the chest. Up to the present time about 200 operations have been reported. Not only does the suppuration cease, but life has been saved, and in the majority of the cases a certain amount of function of the lung has been restored. Vesicular breathing was observed over the entire lung by Schede, which statement has been corroborated by

FIG. 179.

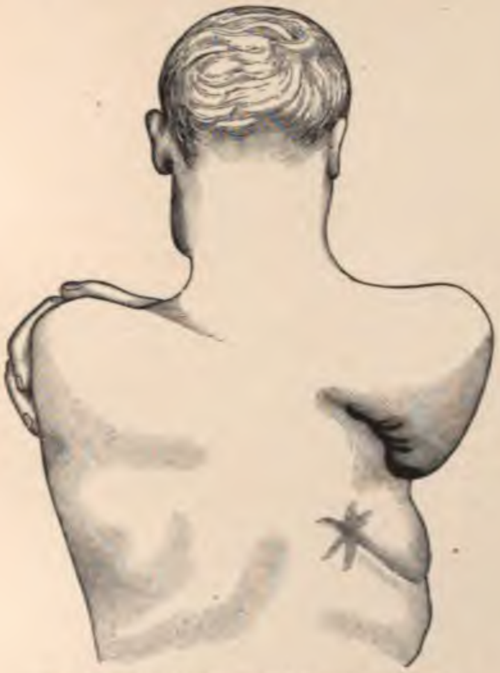


Retraction of the flap covering an empyema cavity.

other authors. Expansion is due partly to the traction of the adherent muscles of the shoulder-girdle and of the arm.

There are cases in which the lower portion of the lung does not expand because the boneless chest-wall in this region does not favor the entrance of air. In these cases the lax thoracic wall moves with respiration and is sucked in during inspiration by the diaphragm and expands during expiration. During attacks of coughing it may bulge outward, very much like a ventral hernia. Gross assumes that the expiratory bulging is produced by distention of the collapsed lung with air. In the case depicted in Figs. 179 and 180 this could not be proved. On the other hand, it was shown that the variation was due to intra-abdominal pressure. The bulging could be produced by keeping the glottis open and pressing upon the abdomen.

FIG. 180.



Bulging of the flap covering an empyema cavity.

After the operation the deformity of the vertebral column, which is marked in severe cases, disappears. This is evident, because the spine is bent by the contracting fibrous pleura and ceases the moment the ribs and fibrous tissue are removed. The function of the corresponding arm is interfered with at first, but is rapidly restored.

The advantages of Schede's operation are as follows: 1. In very large cavities it is the only means of obtaining recovery. 2. Even in small cavities it furnishes the best possible opportunity for the chest-wall to adapt itself to the collapsed lung. 3. The fibrous pleura may be removed if it forms an obstruction to recovery. This is especially important when the pleura itself contains tuberculous granulations. In cases in which there is no tuberculosis, or in which there is no especial thickening or calcification, the author does not consider excision of the costal pleura absolutely necessary. 4. Open treatment of the wound in the pleura influences favorably the recuperative power of this membrane. A pleura that has previously presented a slimy appearance looks fresh and shows a tendency to become covered with granulations. 5. The function of the lung is restored to a certain degree and the deformity of the vertebral column disappears.

MODIFICATIONS OF SCHEDE'S OPERATION.—Helferich first resects the rib immediately above the sinus-opening. He then makes a median incision upward over the cavity and incisions at either end forward and backward. Two flaps are made in this way that can be turned into the cavity from in front and behind. Instead of resecting the ribs subperiosteally, he divides the entire thoracic wall over the cavity, including the ribs, with cutting forceps. Hemorrhage is slight and the operation can be done rapidly.

Beck and Krause resect a rib over the middle of the cavity first. Secondary incisions are made upward or downward according to the conditions found. This method has the advantage of giving accurate information regarding the conditions present and guides the subsequent steps. In extensive operations a cross-incision with four flaps may be made as recommended by Gross.

In cases in which the size of the cavity prevents completing the operation at one sitting and at the first a U-shaped small flap is made with resection of a few ribs, there is the disadvantage that the fresh wound becomes infected by the pus from the upper portion of the cavity. The flap contracts, and when it is necessary to keep the sinus open to furnish sufficient drainage, at the same time allowing the flap to adhere elsewhere, it must be dissected up at the second operation. Sudeck avoids this disadvantage successfully by performing the operation in two regions independently of each other. At the first sitting the ninth and tenth ribs were resected throughout their entire length and the sixth and seventh ribs were resected subperiosteally through a second parallel incision. This flap was pressed into the cavity in the chest and fixed in position. The flap healed without trouble, because the secretion from the upper portion of the cavity ran out through the upper wound. (Fig. 179.) The upper portion of the cavity, which contracted under packing, was treated in the same way at a second sitting when the fifth and fourth ribs and the lower half of the scapula were resected. The intercostal tissue and the muscles of the resected portions of the scapula were included in the second flap. The cavity healed in two months and the function of the upper lobe of the lung was restored to a considerable degree. Fig. 180 shows this patient after recovery. The deformity is comparatively slight.

Jordan and Krause obtained good results by combining Schede's method with that of Délorme.

Decortization of the Lung (Délorme).—Délorme removes by operation the fibrous pleura covering the lung. Schede attempted this, but abandoned the method on account of the hemorrhage. Délorme resects temporarily the thoracic wall by turning back a flap containing skin, muscles, and bone, and removing the fibrous masses representing both pleuræ by blunt dissection or with a knife and scissors. The flap is then replaced. In France the success of this operation has been fairly good. The results are doubtful, because the lung does not expand in some cases, although the fibrous cortex has been removed. According to Délorme, there is no way of ascertaining before the operation whether the lung will expand or not.

Summary.—It is impossible to say which operation should be used in any given case, because the method of operation in empyema varies just as much as the cases. The method used will depend upon whether one has to deal with a tuberculous pleura with a large or small cavity, or whether the entire thorax on one side is involved, and upon the condition of the patient. It cannot be determined beforehand what the patient will stand, but one of the chief conditions of success is not to tax the patient too much at one time. One should decide whether the removal of the suppuration or whether a more extensive operation should be done for the purpose of improving the function of the lung. A great variety of incisions and methods have been recommended, and it is improbable that any two operators would do the same operation in any given case. If any attempt at forming rules is to be made, the author would feel inclined to follow the directions below: 1. First determine accurately the extent and the nature of the cavity. 2. Before operating attempt to diminish the size of the cavity or obliterate it by aspiration. (Brandt, Perthes.) The success is tested from time to time by measuring the amount of fluid that the cavity can hold. 3. Use Simon-Küster's operation only in small cavities that are not tuberculous; in others the open methods are to be preferred. 4. With large and irregular cavities more accurate apposition is obtained by Schede's operation. 5. If possible, do the operation at one sitting, but do not tax the patient too much. Generally speaking, Schede's U-shaped flap operation is to be preferred because the muscle attachments are preserved. 6. Determine beforehand, if possible, whether the operation can be done at one sitting or not. In doubtful cases Beck-Krause's exploratory incision should be used. If it is evident that one operation will not give the desired result, plan to have the individual operations independent of one another. The flaps should be made according to the conditions present. 7. Remove the costal pleura when it is tuberculous or calcified, or interferes with recovery on account of its thickness and density. In other cases removal of the fibrous masses is not absolutely indicated. 8. Try decortization of the lung (Délorme) when other methods fail.

TUMORS OF THE PLEURA.

Malignant Tumors.—There is a peculiar primary tumor of t pleura, the so-called endothelial carcinoma. This variety of grow was first described by E. Wagner, and later by Schulz. Fränk has recently called attention to this condition and given it the nan lymphangitis prolifera. According to Lenhartz and Lochte, 18 cas have been reported up to the present time. There is diffuse thickenii of the pleura, which resembles macroscopically ordinary fibrous thicl ening. Microscopical examination shows, however, that there is a extensive new growth of endothelium. Clinical examination revea marked dulness and compression of the lung. Exploratory punctu in Fränkel's case showed dark blood. Lenhartz and Lochte obtain a chocolate-colored fluid which contained characteristic nests of cell The treatment is, of course, palliative.

Although primary tumors of the pleura are uncommon, secondai carcinoma and sarcoma have been observed quite frequently. Tl primary focus is in some neighboring organ, such as the lung, tl mediastinum, the œsophagus, or the kidneys or may even be in son distant tissue. Malignant tumors of the pleura are probably alwa associated with an effusion. This may be serous or sanguinous, clouded on account of abundance of detritus. After removal of tl effusion a certain amount of dulness persists on account of the tumo This may attract attention because of its unusual position.

Diagnosis.—The diagnosis is sometimes made when an attempt aspirate shows that the needle has entered a tumor which offers co siderable resistance and when no fluid is drawn off. One should n rely on aspiration of particles of the tumor. Generally speaking, tl diagnosis will be evident after demonstrating the presence of a prima tumor or when there is rapidly increasing cachexia without fever.

Treatment.—When there are severe symptoms due to the pressu of an effusion this should be removed. Too much fluid should not b removed at one time because the exudate accumulates rapidly, and tl interference only hastens the end. The tumors that arise in the ches wall and attack the pleura secondarily are of especial surgical intere because they are the only tumors of the pleura that may be success fully treated. The author emphasizes again that one should not hes tate to remove a considerable portion of the chest-wall with the cost pleura if necessary, especially if a permanent cure depends upon tho oughness of the operation, because experience shows that the woun heals kindly. The lung expands quickly under a tight bandage.

ECHINOCOCCUS OF THE PLEURA.

Echinococcus cysts are rarely found in the pleura. When presen they are usually secondary to disease of the lung or some abdomin organ, although they may occur primarily in the pleural cavity.

Symptoms.—The symptoms are those of any tumor of the pleur

There is circumscribed dulness, the upper margin of which is curved, according to Unverricht. The circumference of the corresponding half of the chest is said to be considerably increased. Fever is absent.

Diagnosis.—An absolute diagnosis can only be made by exploratory puncture. This will show characteristic fluid. It is clear as water, of low specific gravity, contains an abundance of sodium chloride but no albumin, and gives the Bernstein acid reaction. The diagnosis will become absolute as soon as hooklets or membranes with the well-known lamellar arrangement are found. It seems almost pathognomonic of echinococcus to have an eruption resembling urticaria follow the puncture.

Treatment.—The treatment must be radical. The results of aspiration are poor, according to Maydl's statistics. Of 16 patients treated in this way, 11 died; some from empyema and some from suffocation, due to perforation of the bronchus. After making a flap of sufficient size, as many ribs should be resected as is necessary to expose the tumor completely. It should be radically removed.

CHAPTER XIV.

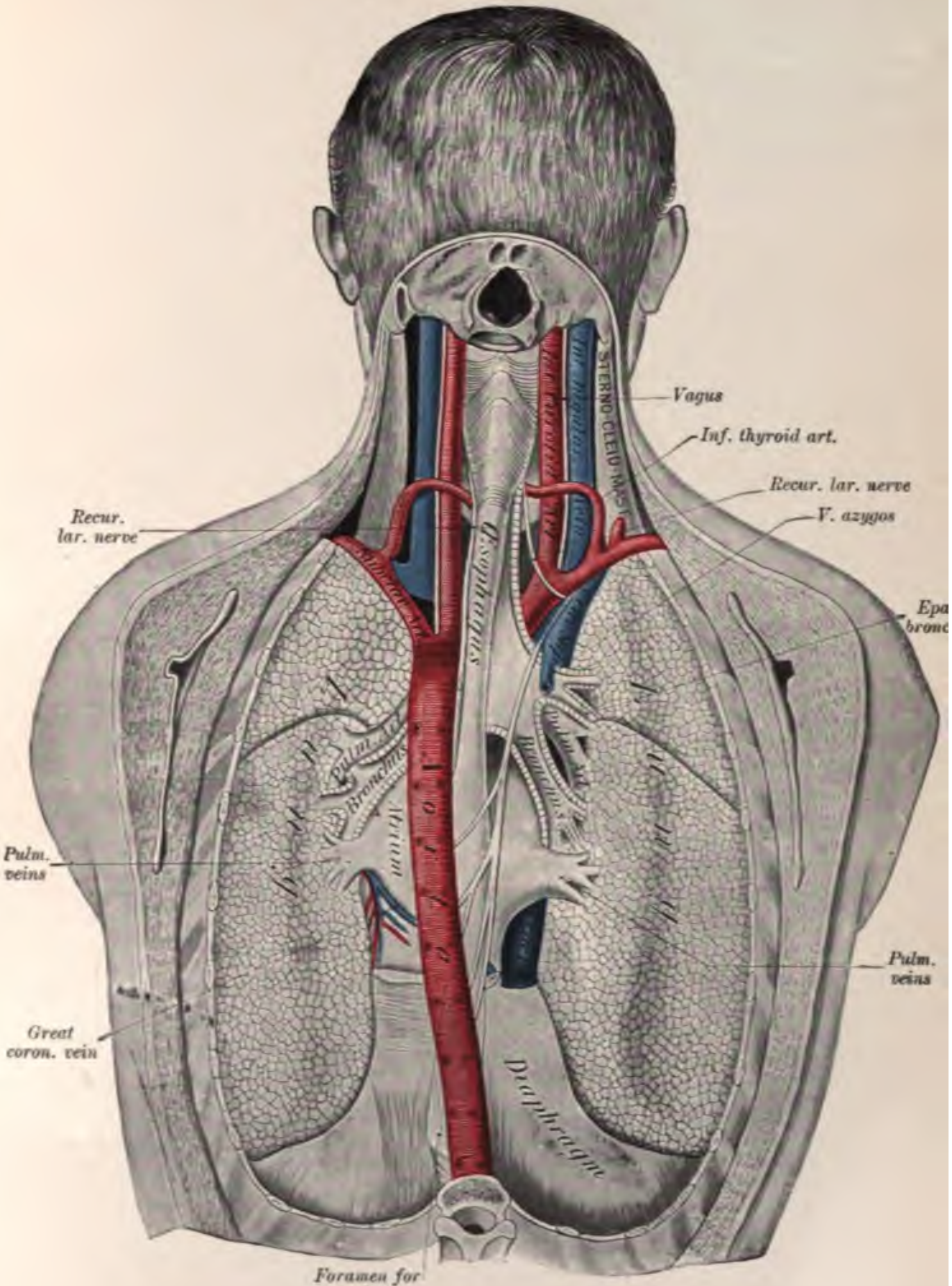
SURGICAL DISEASES OF THE LUNGS.

A MONOGRAPH on surgery of the lungs, written by Tuffier in 1897, includes 306 cases with a death-rate of 29 per cent. In 29 aseptic operations (prolapse of the lung, new growths, tuberculous nodules) the mortality was 24 per cent.; in 60 cases of echinococcus, 10 per cent.; and 35 per cent. of 216 cases of septic operations. Of these, 36 were cavities, 49 abscesses, 45 bronchiectasis, 11 foreign bodies, 77 gangrene, and 1 actinomycosis. The increase of operations and the diminished mortality of late years indicate the success of surgical interference in this region.

General Technic.—Many dangers and difficulties accompany operation upon an organ so necessary to life as the lung. These conditions are frequently underrated. The mechanical conditions make it difficult to determine the diagnosis. The intrathoracic organs are not directly accessible to examination on account of the unyielding chest-wall. Physical diagnosis does not always give the desired information regarding location, extent, and multiplicity of lesion. The mechanical obstructions during an operation consist, first of all, in collapse of the corresponding lung, pneumothorax, and the presence of a large cavity with stiff walls, which remains. Adhesions are necessary for the success of an operation but mechanical conditions may interfere with their formation. Finally, it is often almost impossible to determine whether the disease is still localized or has become a diffuse process involving a large portion of the lung, or whether there are multiple foci.

Thoracotomy precedes, of course, any operation upon the lung. It is not impossible that simple division of the intercostal tissues may at times be sufficient to reach any abscess near the surface of the lung, the walls of which are intimately adherent to the thorax. The author advises, however, even in favorable cases of this sort, always to furnish adequate space by resecting ribs, especially since at times it is impossible to secure healing of extensive abscess cavities of the lung unless the ribs have been resected. Ollier's observations with reference to curvature of the spine and interference with respiration do not alter the author's opinion in this regard, inasmuch as Ollier's observations have not been corroborated by other authors, and because dangers of this sort can be avoided. Surgeons who have had experience with the former methods of aspiration, and who have repeatedly seen fatal hemorrhages and rupture of abscess cavities in the bronchi, will be less liable to refrain from resecting ribs.

PLATE XIV.


Vagus
Inf. thyroid art.
Recur. lar. nerve
V. azygos
Recur. lar. nerve
STERNO-CLEID-MAST.
Œsophagus
Epa
bronc
Pulm. Art.
Bronchus
Atrium
Aorta
Pulm. veins
Pulm. veins
Great coron. vein
Diaphragm
Foramen for œsophagus

Thoracic Contents Seen from Behind. (Joessel.)

This operation is done in the same way as in the case of an empyema. The site of operation depends upon the situation of the focus in the lung. The incision is made directly over the rib in its longitudinal axis and injures no vessel of any size or nerve of importance. After dividing the periosteum it should be lifted off carefully with an elevator, the rib divided with bone-scissors or a wire saw, and the intervening portion removed. In the majority of cases this procedure does not give sufficient space. The rib immediately above or below may be resected in the same way through the same incision. If it is desirable to resect more than two ribs, it is best to make a flap-incision in the skin. When a considerable portion of the chest-wall is to be resected, it may be advisable to open the chest in such a way that the opening may be partially or completely closed again without resecting ribs. This may be done by making a flap which includes the skin, the soft parts, and the ribs down to the pleura. This procedure is especially to be recommended in aseptic operations. After dividing the chest-wall in this way and exposing the pleura over the seat of disease, one will be obliged to decide whether the pleuræ are adherent. This is important because the question of adhesions is directly related to the possibility of further operative interference. Generally speaking, one should never operate except when the lung is adherent. Pleurisy or pneumothorax, etc., superadded to the condition already present, constitutes grave complications, not to mention having the affected lung collapse and thereby change entirely the seat of the disease.

Pre-existing pleurisy and long-continued disease are usually considered to indicate the presence of adhesions. However, retraction of the intercostal spaces and inspiratory deepening and diminishing respiratory displacement of the lower margin of the lung are far more reliable indications. Pain is of little value in this respect. During the operation the spotted appearance of the pleura and thickening will be more apt to indicate adhesion. Personally, the author considers that the introduction of a needle is not without danger. In the absence of adhesions it will move with respiration, whereas if adhesions are present it will remain motionless. Sapiejko recommends the use of a manometer connected with an aspirating-needle. If the needle enters the pleural cavity, the mercury will sink; whereas if there are adhesions, there will be no change in the column. There is no free pleural space, so that the needle will be obliged to push the lung ahead of it without injuring it. Aside from the danger associated with these methods of examination, they have been shown to be unreliable.

When no adhesions are present, or very slight adhesions, it is necessary to produce them artificially before progressing with the operation. The various methods that have been customary up to the present time have been investigated by Quénu and Longuet. When the wound healed by first intention it was shown that no adhesions formed. The old methods were ignipuncture, acupuncture, electrolysis, cauterization, packing, and direct suture. Quincke's results are more favorable. After resection of the ribs he packed down onto the costal pleura and treated the wound with zinc chloride paste for two or three weeks before opening. König saturated a piece of cotton with zinc chloride paste and packed it into the wound. In about half an hour the caustic penetrates the tissues a few lines and is then removed. It is much simpler and just as efficient to pack the wound down to the pleura with iodoform gauze.

Of late years the tendency has been to use sutures, and the author believes that a suture is the most accurate method in suitable cases. It enables operating at one sitting, which is very important in urgent cases, and the relation of the focus of disease to the chest-wall is not disturbed. Fixing the lung in position is rendered much easier by increasing the air-pressure in the bronchi. This takes place, as is well known, in coughing, which led Délorme to make use of incomplete anæsthesia in these cases. D'Antona recommends a similar procedure. He compresses the healthy side and excites coughing, so as to expand the diseased lung and force it into the wound. Roux made use of a suture in 1892. The author prefers interrupted catgut sutures. Pneumothorax with its dangers and infection of the pleura in septic cases need not be especially feared after the placing of circular sutures with subsequent packing. When the pus focus is very near the surface, it may happen that the pleura becomes infected along the needle-track. In cases of this sort an incision should be made over the lowest point of the pleural cavity, just as in the treatment of abscesses that have ruptured into the pleura. In cases that are not especially urgent the second step of the operation may be delayed several days after suturing the pleura. The wound should be thoroughly packed in these cases.

Exploratory punctures and preliminary operations have been recommended so as to diminish the difficulty in making the correct diagnosis. Tuffier recommends stripping off the parietal pleura for the purpose of examining the lung indirectly. Bazy is opposed to this method, and recommends direct palpation of the lung after opening the pleural cavity. Monod was unable to find the seat of the disease after opening the pleural cavity and palpating the lung, although exploratory puncture showed pus.

Extrapleural thoracotomy as done by Tuffier consists in resecting the chest-wall down to the parietal pleura. This membrane is then separated from the thorax without opening the pleural cavity and the lung is palpated through the membrane. This procedure means extensive interference and does not always give the desired information. Lejars reports 2 cases in which this method was unsuccessful, although the pleura was separated for a considerable distance. The same author was unable to detect the pus focus even after incising the lung-tissue to the extent of about 6 cm. The autopsy showed that this incision, which was made without profuse hemorrhage, passed within 1 cm. of the pus cavity.

The author believes that exploratory puncture with a large canula or syringe is far more valuable in determining the seat of disease after the chest-wall has been opened. Although he believes that exploratory puncture is an unsafe and dangerous manipulation when the chest has not been opened, yet after thoracotomy it seems to him of especial value. In cases in which the pleura is adherent and the puncture shows pus or echinococcus cavities, etc., the needle may be left in place and used as a guide for the knife. It is not advisable to remove the needle before incision because one may miss the cavity. Operations upon the lung itself are called pneumotomies when the lung is simply incised, and pneumectomy when a portion of the lung is removed.

It is a matter of dispute whether it is best to use a knife or the cautery for operating upon the lung. The author has always used a cautery, but believes that in many cases a narrow-pointed knife would be equally as serviceable. The hemorrhage is not so great that it may not be easily checked by packing as a rule. If the tissue is indurated with a few vessels, a knife is undoubtedly to be preferred, but when the tissues are very vascular this instrument is counterindicated. The track made with a cautery will be more easily kept open in suppurating disease of the lung. It is advisable to make a liberal incision, because it is much easier to pack with gauze afterward. Digital examination through the incision will give sufficient information regarding the extent of the abscess. If it is not possible to find the focus, it will be found that in many cases the matter will spontaneously break into the packed wound later. When rubber-tissue drains are used in the after-treatment, these should be changed at regular intervals, because when left in place for any length of time they may erode the veins and cause severe hemorrhage. This same accident may happen after packing with gauze, as in a case operated on by the author for bronchiectasis. On removing a deep packing of iodoform gauze on the fourth day after operation a hemorrhage followed which left the patient, who was twenty-eight years of age, pulseless within a few moments. The cavity, about the size of a hen's egg, was packed tightly with gauze and an infusion of 2½ litres of salt solution given. Recovery ensued.

It seems to be of value to pack loosely around the rubber tube drain down to its extremity. The antiseptic solutions formerly used for washing out the cavity are no longer recommended, because other portions of the lung may be infected through some bronchus communicating with the abscess cavity.

After what has been said it is unnecessary to consider especially pneumectomy. If there is only one focus (cyst, tumor) which can be removed *in toto*, the wound in the lung can be closed with fine catgut sutures. The author has repeatedly observed cases in which the sinus in the lung did not heal after the secretion had ceased. In these cases an attempt was made to cover in the lung with skin-flaps after freshening the edge of the wound in the lung.

The anæsthetic and the position of the patient remain to be briefly mentioned. General anæsthesia is necessary in most cases in spite of the danger to the emaciated and weakened individual. The author prefers chloroform. Ether is objectionable on account of the irritating effect on the respiratory tract. Partial anæsthesia has been recommended so that coughing may be excited to distend the lung. It is best to make use of complete anæsthesia during the first steps of the operation until the lung-tissue has been incised. The subsequent indications will depend on the conditions found. Vomiting, gagging, and change of position are at least as dangerous to the patient as complete anæsthesia. Local anæsthesia or infiltration anæsthesia is impracticable on account of the excitement and fear of the patient, which make it impossible to operate with ease.

The position of the patient is important, because in the majority of the cases one will prefer to operate behind and below the angle of the scapula. This region is most accessible when the patient lies on the healthy side. The author always avoids this position as much as possible, so as not to smear the pus over the healthy portion of the lung. It is better to have the patient turned half to one side and support the shoulders and pelvis, so that the back is downward; this position is a little awkward. When the focus in the lung is in front, it is evident that the position should be dorsal.

The operations above described are employed in inflammatory processes of the lung, abscesses, gangrene, bronchiectasis, tuberculosis of the lung, and where there are tuberculous cavities. Parasitic diseases which are of surgical importance are echinococcus cysts and actinomycosis of the lung.

ABSCESS OF THE LUNG.

This condition is comparatively rare. Laennec observed that croupous pneumonia was the most frequent cause of abscess of the lung. Traube and Lenhartz are of the same opinion, whereas v. Leyden believes that abscesses secondary to simple pneumonia are extremely rare. According to Tuffier's statistics, 25 of 49 cases operated upon followed pneumonia, although it has been doubted whether these pneumonias were all of the ordinary croupous variety. Of late years influenza pneumonia has been considered of etiological importance. Traube believes that abscess of the lung following pneumonia is due chiefly to compression or thrombosis of a vessel, causing necrosis of the pulmonary tissue. On examining the abscess pus it was shown that suppuration was due to infection with staphylococci and streptococci. *Bacillus coli communis* may also produce suppuration. In these cases the infection is secondary. The author is aware that in the vast majority of cases croupous pneumonia is produced by Fränkel's pneumococcus, and that this organism may produce true suppuration and general sepsis, so that it is not always necessary to assume the presence of a mixed infection.

The remaining varieties of abscess of the lung have in common the peculiarity that they develop in lung-tissue that has been healthy previously. Embolic abscesses belong to this group, and develop when infectious material is deposited in the lung with the embolus from the primary focus. An abscess develops first of all where the embolus becomes lodged, and not behind the embolus as in the case of infarctions. Of the various septic infections, puerperal fever is first to be emphasized. In these cases there may be a number of abscesses in the lung instead of a single abscess, so that the clinical picture is that of pyæmia.

Abscesses due to foreign bodies are less frequent. The objects may be buttons, coins, bullets, needles, teeth, particles of bone, sheaf of grain, etc. Foreign bodies usually reach the right bronchus, because this favors the entrance of substances on account of its more vertical course. Blades of grass or kernels of grain are frequently the cause of abscesses according to Lenhartz. He reports 16 cases of this sort, 11 of which developed an abscess. There were 2 fatal cases of this number and 1 fatal gangrene of the lung.

Injuries of the lung not infrequently cause gangrene, but are rarely followed by abscesses. The so-called perforating abscesses, emphasized by Stokes, are comparatively common. Abscesses of the liver, subphrenic abscesses, and empyemas belong to this group. Caries of the spine or of the ribs, or suppurating bronchial glands, echinococcus of the liver, ulcers of the stomach, and appendicitis are also to be mentioned in this connection.

Leyden names those cases of simple necrosis with ulceration, developing in the indurated lungs of old individuals, chronic abscess of the lung. These consist in ulcerating cavities that increase slowly in size and are filled with pus developed by necrosis of the chronic inflamed tissue.

Symptoms.—The presence of an abscess is indicated with the greatest degree of certainty by the condition of the sputum. It may be coughed up in large quantities. Sometimes it is almost pure pus, cream-like and without odor; whereas in other cases it may be mouldy and have a sour or sweetish odor. The odor becomes fetid when decomposition is present. A grass-green sputum has not infrequently been observed preceding rupture of an abscess which developed secondarily to lobar pneumonia. When the hæmatoidin crystals are abundant, the color may be brownish green or yellow. Trousseau describes a chocolate-colored sputum; and Lenhartz reports a profuse prune-juice-like expectoration which continued for months in a case of abscess of the right lower lobe. The presence of tabs of lung parenchyma is characteristic. These may be several centimetres in length. Under the microscope connective tissue and elastic fibres of the alveoli may be recognized. Not infrequently there is a deposit of granular black pigment. Fatty crystals are present as well as the hæmatoidin crystals of Leyden and Traube. These are light or dark brownish-red glistening rhombic crystals or delicate bundles of needles which radiate from one or both ends and often have a rhombic crystal in the centre.

Diagnosis.—The temperature-curve in abscess of the lung is not characteristic. When the abscess follows pneumonia, the temperature of the primary disturbance does not drop to normal. The intermittent rises indicate a complication. Auscultation and percussion give the desired information much less frequently than might be expected, because it is difficult to differentiate an abscess from an infiltration of the lung of equal size by these signs alone. When a tympanitic note over an area previously dull follows an attack of coughing, during which a quantity of purulent expectoration is voided, following which the temperature drops, while the signs of cavity alternately disappear and reappear, it may be concluded that there is an abscess of the lung provided a pleural accumulation of pus can be excluded. The abscess must communicate with the bronchus, and the walls of the abscess must be sufficiently pliable to allow the purulent contents to escape. The diagnosis will be easier, the more characteristic the expectorate. Abundant yellow creamy sputum, elastic fibres, and hæmatoidin crystals with signs of a cavity, will be deciding data.

Gangrene of the lung differs from abscess in the foul expectorate. Elastic fibres are usually not found in gangrenous expectorate and hæmatoidin crystals are few in number. The sputum of phthisical patients may be recognized by the abundance of myelin drops and the absence of macroscopical bits of parenchyma. The presence of tubercle bacilli is conclusive evidence. Experience has shown that abscesses are more common in the lower lobe of the lung, whereas tuberculous cavities are usually found in the upper lobes. Elastic fibres are probably always absent in bronchiectasis. When an abscess ruptures into a bronchus from some neighboring region (empyema, abscess of the liver, etc.), it will be difficult to determine whether an abscess of the lung is present or not.

The Röntgen rays have become a valuable diagnostic aid in abscess, gangrene, cavities, and tumors of the lung. The sharp, clear pictures render abscesses and gangrenous portions easily recognized.

Prognosis.—The prognosis depends largely upon the etiology, and the outlook is not so hopeless as is generally believed. The number of recoveries has increased rapidly with improvement in technic, and the author is of the opinion that the results will be still more favorable when treatment is commenced in the early stages. The best results are obtained in cases following pneumonia.

Treatment.—As regards treatment, the author is obliged to confess that some cases heal spontaneously with careful nursing. In the majority of the cases, however, a cavity with stiff walls that continually secretes persists because dense bands of fibrous tissue unite the lobe of the lung to the unyielding chest-wall and the cavity is thus held open. In these cases medical treatment will not be able to remove the mechanical obstruction to recovery. Quincke believes that abscesses should receive surgical treatment only when they show no tendency to diminish in size. The author is of the opinion that this indication is too indefinite. He holds that a recent abscess should be treated at once. No general rules for operative interference can be given, the decision depending in the individual case upon the conditions present.

Exploratory puncture before operating, for the purpose of locating the abscess, is dangerous and should be avoided. On account of the small size of the abscess it is not always possible to locate the pus with a needle.

The results of operation upon abscesses of the lung are given in Tuffier's statistics, which comprise all the cases up to 1897 reported. These statistics contain 49 cases of abscess of the lungs, 47 cases of bronchiectasis, and 11 cases of abscess secondary to aspiration of foreign bodies. Of 99 cases, 23 followed lobar pneumonia, and 6 were produced by septic emboli. Resection of one rib gave sufficient exposure in 19 cases, and in 9 cases several ribs had to be resected. The pleuræ were adherent in the majority of the cases. In 4 cases the adhesion was only partial, and in 9 cases there were no adhesions whatever. The pleura was sutured 3 times. In 4 cases pneumothorax developed at the time of operation, and was only slight in 2 cases with no alarming symptoms. In one case, however, it complicated the operation, and in the other the fatal termination was hastened by this accident. Of 43 operations, there were 33 recoveries and 10 deaths. In 7 cases the abscess could not be found, and only 1 of these patients survived. According to Garré's statistics, 77 of 96 cases of abscess of the lung operated upon recovered, whereas the other 19 died.

The prognosis in abscesses due to foreign bodies is far less favorable. In the majority of the cases the foreign body is not found: according to Tuffier, only once in 11 cases. On the other hand, cases have been reported in which the foreign body was expectorated spontaneously later. Schmidt reports the case of a girl thirteen years old who coughed up a piece of grain that had remained in the lung for seven and a half years and produced constant symptoms. Leoni and Koch report a case in which a cherry-stone was coughed up with considerable pus after having been in the lung for nineteen years. The author knows of a case in which the glass eye of a doll was coughed up after a year. The pulmonary symptoms during this time were slight.

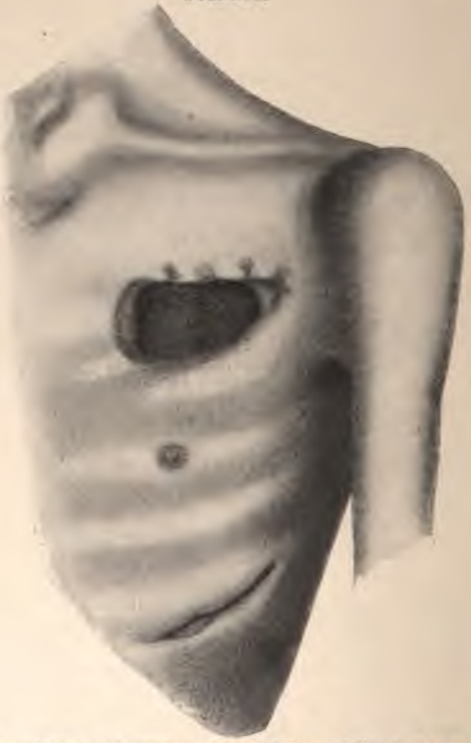
In the majority of cases the changes in the lung are so extensive that recovery cannot take place, and for this reason immediate surgical interference is to be recommended. A considerable number of the foreign bodies may be located with the Röntgen rays. Certain of these obstacles may be removed from the bronchi through a tracheotomy-wound, when their size and shape and the manner in which they have become lodged make it impossible for them to be coughed out. The prognosis of abscesses due to embolism is equally unfavorable.

Attention has been directed chiefly to acute abscesses of the lung, because the chances of recovery are more favorable. The results are uniformly unfavorable when the operation is done late and the patients have become run down and unable to withstand even moderate interference, and pneumonia not at all.

GANGRENE OF THE LUNG.

This condition is a necrosis of the lung-tissue produced by putrefactive bacteria, and is either circumscribed or diffuse. The condition is comparatively rare, and is met with more frequently in men than in women. In the vast majority of cases it follows lobar pneumonia or pneumonia due to a foreign body. Alcoholics, cachectic people, and diabetics appear to be especially prone to infection. Gangrene is not infrequently preceded by a hemorrhagic infarction and by embolism shutting off the circulation. This is especially the case when the embolus is derived from some septic thrombus of the veins, as in puerperal processes, decubitus, and caries of the petrous portion of the temporal. Trauma may be followed by gangrene of the lung, as emphasized by Leyden and Stokes. Stab-wounds, gunshot-wounds, fractures of the ribs, and laceration of the lung-tissue must be mentioned in this connection. Bronchiectasis and ulcerating cavities may produce gangrene when the stagnant secretion undergoes decomposition, erodes the bronchial wall, and infiltrates the surrounding parenchyma.

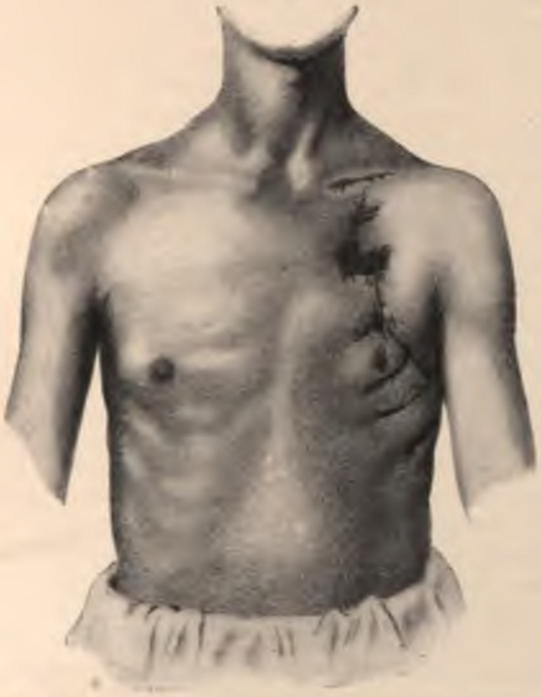
FIG. 181.



Gangrene involving the greater portion of the left lung, following a penetrating wound of the chest.

Leyden's statement that in individual cases metastatic gangrene of the lung may develop in the course of caries of the middle ear from small thrombosed veins in the petrous portion of the temporal bone, deserves especial mention. It may be impossible to demonstrate these veins, but in the absence of any other conceivable cause this connection must be assumed to be present. Volkmann believes that in these cases the infectious material passes through the Eustachian tube directly into the pharynx and trachea, just as in the case of suppurating cancer of the jaw and tongue, diphtheria of the larynx, or after extensive operations in the mouth and nose. Suppurating bronchial glands, retropharyngeal abscesses, and cancer of the œsophagus may be followed by aspiration of suppurating and putrid portions of tissue secondary to rupture of the bronchi, or may be directly aspirated. On passing an œsophageal sound in a case of cancer of the œsophagus the author observed a rapidly developing gangrene of the lung. This condition may also be secondary to carcinoma or sarcoma of the lung.

Fig. 182.



Healing after resection of the clavicle and most of the ribs on the left side.

Circumscribed gangrene of the lung may vary in size from that of a pea to that of a fist, and is more frequent on the right than on the left side. If the focus is superficial, the lung will be retracted and the pleura discolored, reddish yellow, devoid of lustre, and covered with fibrin. Recent gangrenous areas present on section a dirty greenish-brown or black appearance. The focus in the early stage is somewhat denser than the surrounding tissue, but soon begins to soften at the periphery, becomes friable, soft, and stinks. The focus gradually separates from the surrounding tissue and a foul-smelling jagged, friable mass is found within the cavity. Sometimes the contents are brown or greenish black and contain fragments of tissue in a putrid mass, whereas the walls of the cavity are lined with ragged, tab-like masses of necrotic tissue.

Diffuse gangrene may be secondary to circumscribed processes. The primary cause may be a bronchiectasis or some other cavity, more rarely a purulent infiltration during pneumonia. Gangrene is frequently secondary to rupture of putrefying foci in the vicinity of the lung or to aspiration of foul shreds of malignant tissue from the upper portion of the air-passages. Diffuse gangrene not infrequently involves an entire lobe of the lung. Both varieties, and especially the diffuse form, may be associated with multiple metastases. Virchow has described abscesses in the brain secondary to these conditions. In the majority of the cases examined bacteriologically *Staphylococcus pyogenes albus* and *aureus* have been found in pure cultures. Leyden and Jaffé found several varieties of fungi in the gangrenous foci. They were of the opinion that one of these was a derivative of *Leptothrix buccalis*, and named it *Leptothrix pulmonaris*. Other authors have described a variety of microphyte belonging to the series of micrococci and resembling in size the staphylococci.

Symptoms.—The most important evidence of gangrene of the lung is the sputum. As a rule this is so characteristic that a diagnosis can be made by carefully examining the expectorate. The extremely repulsive, foul, cadaverous odor is especially noticeable. Sometimes the odor is stale and acid, and the quantity expectorated may be 600 c.c. or more in twenty-four hours. The color is greenish gray or dirty brownish red, and on standing the sputum separates into three layers: the superficial layer is frothy, dirty yellow or grayish green, and mucopurulent, containing scattered mucopurulent masses; the middle layer is aqueous, lighter in color, and more or less cloudy, containing shreds of mucus as flocculi or as pollywog-like tabs; the lower layer is a dirty greenish-gray sediment, consisting of pus and detritus, which contains Dittrich plugs of varying size and of foul odor. There also may be small blood-clots. A sputum of this sort indicates first of all that there is a process of decomposition in the lung. The question arises always whether the process is in the interior of intact bronchi, or whether it is associated with destruction of the lung-parenchyma. Traube mentions three conditions which indicate destruction of the lung-parenchyma: *a*. First, when the physical signs of a cavity in the lung develop acutely. If, on the other hand, these symptoms are present when the case comes under observation, there may have been a pneumonia which has continued for a considerable time and produced abscesses or induration of the lung-parenchyma without bronchiectasis and without a vestige of gangrene. *b.* When in a sputum, as described above, microscopical bundles of elastic fibres are found that are grouped in such a way as to resemble the arrangement of the fibres in the lung-tissue. It should be mentioned that elastic fibres are comparatively rare in the expectorate of gangrene of the lung. Their absence is said to be due to the presence of fermentation. *c.* When there are found in the foul expectoration irregular, elongated, grayish tabs with fine black lines or dots, resembling tinder, and the microscope shows an abundance of black pigment particles crowded close together in the amorphous translucent material. Dittrich's plugs contain an abundance of fatty crystals scattered promiscuously or arranged in bundles, besides drops of fatty detritus and bacteria. Frequently smaller foci cannot be detected on physical examination. Larger foci may be recognized in almost every case by the coarse bubbling rales and amphoric breathing even when there is a layer of healthy lung-tissue between the cavity and the chest-wall. The percussion-note will be dull according to the seat and size of the focus. Fever is never absent in gangrene, is usually remitting, and in individual cases resembles hectic fever, and is associated with profuse perspiration and diarrhœa. Frequent chills indicate absorption of larger quantities of putrid material. Coughing and dyspepsia are such common concomitants that they need not be especially considered.

Of complications, there may be mentioned, pyæmia and abscess of the lung, pleurisies with or without infected or purulent effusions. Severe complications may be produced by rupture of the gangrenous focus into the surrounding regions, giving rise to pyopneumothorax; or when the pleura has previously become adherent, rupture may take place through the chest-wall and be followed by infiltration of the subcutaneous tissue with air and pus. Rupture may take place into the mediastinum or through the diaphragm into the abdomen.

Diagnosis.—The diagnosis will lie between putrid bronchitis and gangrene, because in both of these conditions the sputum is alike as far as the odor is concerned. When the expectoration contains tabs of tissue there is no doubt. On the other hand, cases of gangrene occur in which this symptom is not present, and in typhoid, puerperal fever, and other septic processes there may be no expectoration whatever, only some lobular infiltration, and the true nature of the condition is not recognized ante mortem.

Treatment.—Gangrene of the lung may be secondary to infiltration of the parenchyma around the bronchus or due to a distended bronchus with foul stagnating secretion that is undergoing decomposition. For this reason when bronchiectasis is present, one should always promote abundant expectoration as a prophylactic measure. Of the medicinal agents that make the condition more bearable to the patient and his surroundings are to be mentioned carbolic acid and oil of turpentine, which may be used as an inhalation in a 2 to 5 per cent. solution. According to the experience of some clinicians, inhalations of pure carbolic acid and alcohol by means of Curschmann's mask give the best result. Creosote, carbolic acid, and lead acetate may be used internally, although the benefit derived is usually slight.

At the present time the tendency seems to be toward operative interference in gangrene of the lung, especially when the focus is circumscribed. Surgical interference is only indicated and promises success when the disturbance is localized. The prognosis in diffuse gangrene is absolutely unfavorable. The operation is undeniably of great advantage to the patient, because it furnishes an outlet for decomposing material, and obviates the disagreeable taste which makes food repulsive. After opening a cavity, which is preferably done with a cautery so as to avoid infecting the wound, the region is packed firmly with iodoform gauze and not washed out. The putrid expectorate disappears rapidly when the packing is changed every day or so. The fever diminishes and the results are extremely favorable in many cases. The author considers that surgical interference is always indicated in gangrene of the lung when there is empyema. At the same time gangrene of the apex of the lung is much more dangerous and demands immediate interference. When gangrene develops as the result of the entrance of nourishment after rupture of the œsophagus, the symptoms are so acute that operative interference up to the present time has always been fruitless. Cases of diffuse gangrene or cases with multiple foci in one or both lungs, signs of meningitis or abscess of the brain, are all counterindications to operation. The absence of pleuritic adhesions is always unfavorable, but there is no counterindication to operative interference. The most important factor is to operate as early as possible, because the chances of success are much greater.

According to Tuffier's statistics, the majority of pneumotomies have been done for gangrene of the lung. He enumerates 74 cases, with complete recovery in 60 per cent. The accidents happening during an operation in these cases were 9 cases of hemorrhage due to erosion of veins, 4 of which died. According to this author, the absence of pleuritic adhesions does not seem to be so disastrous as generally supposed. The pleura was not adherent at the seat of operation 14 times, although adhesions were present in the vicinity; 6 times there were no adhesions whatever. Of the latter cases 2 died, although the fatal termination was due largely to the severity of the condition itself. In the third and fourth cases the cavity was opened, and in the other two this was impossible. The focus of the gangrene ruptured into the pleural cavity of its own accord two days later in one case, and in another pneumothorax developed. Recovery took place in this case. More than two-thirds of the recoveries were in cases of metapneumonic gangrene, in which the prognosis is much more unfavorable in other cases. Garré's statistics, including 122 casss of operated gangrene of the lung, show 18 recoveries and 42 deaths. Reclus showed in 1895 that about 60 to 75 per cent. of the cases died if not operated upon. Quincke reports 6 cases of recovery, 6 deaths, and 1 improvement with permanent sinus out of 13 cases operated upon. Schwalbe reports 23 cases; 5 acute cases with 1 recovery and 4 deaths; 18 chronic gangrenous abscesses with 5 deaths, 9 recoveries; 2 cases of improvement and 2 cases in which the result was unknown. According to Fabricant, the mortality was 38.5 per cent. in 26 cases. It will be seen from these figures that the results of operative interference are favorable. The author emphasizes again that the prognosis is better when the condition has existed for a short time. The dictum applicable to simple abscesses, that the chances of recovery are less the older the abscess, applies to a much greater degree to gangrenous processes.

One should not advise waiting when there is no doubt of the diagnosis, because spontaneous recovery is improbable.

BRONCHIECTASIS.

There may be a cylindrical and a sacculated distention of the oronchi. Cylindrical bronchiectasis may involve a single branch or several branches, or several lobes of the lung, but affects as a rule the smaller and medium-sized bronchi. When the larger bronchi or medium bronchi alone are involved, the extremity of the distended portion is club-like. When, on the other hand, the dilatation is of the terminal portion, the cut section of the affected portion of the lung will resemble a coarse sponge. The cylindrical variety is secondary to spindle-shaped or rosary-like dilatations. All of these dilatations of the bronchi are removed from surgical interference. As a rule they produce no severe disturbances, and the prognosis is not altogether bad with symptomatic treatment. Sac-like bronchiectasis develops at the expense of the lung parenchyma. A bronchus may be distended in some parts of its course to the size of a hen's egg or may terminate in a sac. Sometimes the bronchus ending in the sac becomes obliterated, leaving a closed cavity—a cyst as it were—the contents of which undergo changes just as in ordinary cysts. Several sac-like dilatations may follow one another closely and form a large cavity that is subdivided by the remaining portion of the bronchus. Sac-like bronchiectases may be very extensive and may involve all the bronchi of the lung. The parenchyma situated between the dilated tubes is more or less shrunken and disappears. Even in cases that are not so extensive the lung-tissue between the cavities is contracted and fibrinous. These fibrous bands frequently extend outward to the thickened pleura, so that the system of cavities is intimately adherent with the thoracic wall. As a rule it is impossible for the cavities to collapse on account of the unyielding nature of the chest-wall. Those regions of the lung not affected by bronchiectasis may show marked emphysema, and in the later stages catarrhal pneumonic foci appear which are probably due to aspiration of infected material from the dilated bronchi.

Congenital bronchiectasis should be mentioned especially. Grawitz reports a case in which one of the lower lobes had been changed to a lax sac with many cavities, presenting a system of spaces opening into one large cavity and separated from each other only by thin dividing walls.

In a certain number of cases the clinical picture is complicated by tuberculosis. One condition does not exclude the other, although it is not common to have them present at the same time. In bronchiectasis the changes in the pleura are so frequent that they have in certain regions been considered to be the primary cause of bronchiectasis. Laennec considers that the condition is due to the accumulation of larger quantities of secretion in chronic bronchitis, whereas Andrae and others are of the opinion that disturbances of nutrition in the bronchial wall are to blame. Stokes claims that the dilatation is due to loss of elasticity of the non-muscular portion of the bronchi on account of some inflammation, with simultaneous paralysis of the muscular layers. Hasse claims that obliteration of the alveoli always precedes the condition described by Stokes. The author believes that coughing producing abnormal pressure in the bronchi and extension of inflammatory processes in the surrounding lung-tissue to the bronchial wall favors the development of bronchiectasis.

Symptoms.—The first symptom is a cough, which is paroxysmal, and is especially common in the morning on waking up, although it may repeat itself several times during the day. As a rule the patients are familiar with the hours when coughing becomes necessary. This symptom may be especially violent in certain positions and disappears entirely when the position is altered, which phenomenon depends on the position of the opening in the bronchi. The amount of expectorate raised at one time may be great, even 500 to 800 c.c., so that one might believe that an empyema had ruptured into the air-passages. The sputum is mucopurulent, yellow, and separates into two layers on standing. The bottom of the glass will be covered with a thick layer of pure pus, whereas the supernatant fluid is thin, slightly cloudy, and almost serous. The odor may be foul or like garlic, or there may be no odor at all. Hemorrhages are not uncommon. There is usually a certain amount of blood mixed with the expectorate and cases of fatal hæmoptysis have been reported. Microscopical examination shows pus-cells, drops of fat, and margaric acid crystals when decomposition has set in. As a rule there are no elastic fibres.

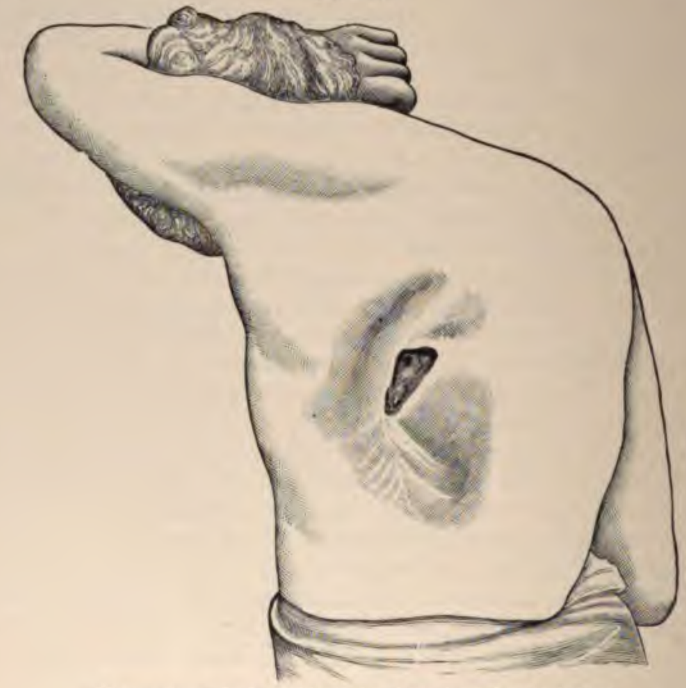
With simple bronchiectasis there is usually no rise of temperature. In a given case the fever would indicate some complication and depends generally upon infection with pyogenic bacteria. The chest-wall is rarely deformed. This condition has been observed when the amount of contraction of the lung has been excessive, or when the pleura has been closely united with the bronchiectasis. In these cases there may evidence of retraction and sinking in of the chest-wall, and even curvature of the spine. The peculiar changes in the hands and feet are known by the name of club fingers. The terminal phalanges become hypertrophied, just as in tuberculosis and cardiac diseases, in which chronic cyanosis seems to be the cause. Percussion and auscultation usually reveal characteristic signs of cavity. There may be more or less pronounced dulness, followed by a resonant tympanitic note according to whether the cavity contains more air or more secretion. This change of percussion-note is also noticed on opening or closing the mouth or on changing the position. Sometimes nothing at all can be heard on auscultation, whereas at other times there may be loud bronchial breathing with coarse moist sonorous râles.

The complications are of importance because the surgical treatment depends chiefly upon their presence. The most frequent and dangerous occurrence is purulent decomposition of the bronchial secretions producing a putrid bronchitis with secondary catarrhal pneumonic processes and finally gangrene of the lung. Metastatic abscess of the brain and purulent meningitis are always fatal. Gerhardt claims that the so-called rheumatoid conditions of patients with bronchiectasis are due to absorption of decomposed pus from the cavities. Emphysema is frequent and important because the subsequent developments may depend largely upon this condition. It has been mentioned that tuberculosis and bronchiectasis may be present at the same time. Suppuration lasting for years is followed by amyloid degeneration of the kidneys. The heart action may become faulty on account of hypertrophy and dilatation of the right ventricle.

Diagnosis.—The diagnosis may be difficult. The presence of tubercle bacilli does not necessarily exclude bronchiectasis, and in these cases recourse must be had to other methods of investigating. It is fair to assume that bronchiectasis may follow tuberculosis, but the reverse is not probable. The history, the position of the cavities, and the habits of the patient are of importance. It may be impossible to distinguish bronchiectasis with foul expectoration and no other physical signs from simple bronchitis. The condition may be frequently confounded with gangrene of the lung or abscess of the lung, especially since these conditions are not infrequently found present at the same time.

Treatment.—Considering the unfavorable prognosis, it will be easily understood why the majority of surgeons prefer not to operate. Tuffier reports 46 cases with 39 cases of pneumotomy, of which 10 died and 7 recovered. Schwalbe reports 15 cases with 6 deaths, 8 improvements, and only 1 recovery. Sonnenburg and Körte report a case of fair recovery. In the older statistics of Mosler, Fenger, Hollisten, Bull, and Runeberg not a single case of permanent cure is reported. Freyhan reports 13 deaths, 7 unimproved, 3 improved, and 2 cures out of 25 cases of bronchiectasis operated upon. One of the recovered cases was affected only on one side. Garré collected 57 cases with 36 cures and 21 deaths. The cause of the unsuccessful results, in the author's opinion, is the multiplicity of the lesion and the great extent of the dilated portion. The author considers that these cases are incurable, unless the mechanical treatment recommended of late, consisting in systematic breathing exercises, manual compression, cold applications, etc., is able to prevent stagnation of secretion and lengthen life. One should differentiate between the cases in which a large number of tubes are dilated and those in which there is only localized dilatation of one bronchus. In the latter case pneumotomy will give satisfactory results and be of the utmost benefit to the patient. After draining the cavity the septic symptoms and the purulent bronchitis diminish, because the pus can find its way to the surface through the wound. König reports that he was enabled to restore two individuals to comparative comfort by operation who had become objectionable to human society on account of their extremely foul expectoration. Besides the subjective relief offered these patients by operation, the dangers are removed that have been mentioned in connection with the accumulation of pus in the cavity.

FIG. 183.



Pneumotomy for bronchiectasis. Open bronchus and sinus.

The author has recently operated upon two patients, a woman thirty-four years of age, and repeatedly on a boy eight years of age, for the removal of multiple bronchiectatic foci. In the latter patient almost the entire upper left lobe of the lung and the upper portion of the lower lobe were resected. Expectoration has ceased, the patient's nutrition is excellent, and he stands a fair chance of recovering completely. The second case is depicted in Fig. 183, showing a sinus with an open bronchus. The method recommended by Quincke, not to open the interior of the lung, but to resect neighboring portions of the chest-wall and favor scar-contraction in this way, does not seem to have met with general approval. It is impossible to state what the indications for operating are in these cases, because the number of observations reported cannot be utilized in this sense and are in themselves incomplete or deficiently described. The author would operate just as in abscesses of the lung only when a circumscribed portion of the pulmonary tissue is diseased. Heidenhain resected with favorable result a large portion of the left lower lobe containing many bronchiectatic abscesses and a carcinomatous nodule.

TUBERCULOSIS OF THE LUNG.

Only localized tuberculosis of the apex of the lung and tuberculous cavities of the lung are of surgical interest.

Mosler was first to attack tuberculosis of the lung directly by injections of carbolic acid and salicylic acid, and opened a cavity with a knife. Later, when the tubercle bacillus was discovered, the infection theory leading to Mosler's experiments was abandoned, and Pepper began to inject iodoform oil. The results of these injections were not such that the method became generally used. In the early eighties numerous animal experiments demonstrated that it was possible to resect not only small portions of the lung, but even a whole lobe. Biondi injected material containing bacilli into the lungs of animals, thus producing tuberculosis which remained localized for a certain length of time. During this time he excised the diseased lung and cured several of the animals which survived the operation. No infection of the other organs was noticed in the cases that recovered. Based upon these experiments tuberculous portions of the lung were resected by Ruggi with fatal results. The operation has not been repeated until lately. Three cases have been reported by Lawson, Doyen, and Tuffier, in which the apex of the lung was resected on account of circumscribed tuberculosis. After recovery no difference could be made out between the two sides on percussion and auscultation, because the remaining portion of the upper lobe completely filled the space. Further investigations have been made by W. Koch, Rochelt, C. Spengler, Kurz, and Reclus. Bull is of the opinion that the opening of tuberculous cavities is only a palliative procedure, and might be justified when the clinical picture is dominated by the signs of the cavity, or when stagnation of secretion causes a rise of temperature, and when the cavity is difficult to empty by way of the air-passages because these have become partly obliterated or plugged.

The above-mentioned cases enable the author to state certain general indications for operative interference in tuberculosis of the apex of the lung. They prove that with the technic of to-day the operation itself is devoid of danger. The chief difficulty lies in the diagnosis and lack of knowledge as to the seat and extent of the focus. The most careful physical examination and even the radiograph may not give the desired information. Even when the operation is limited to foci apparently primary and isolated, one cannot always determine whether and how far bacilli have been carried to other parts of the body. Considering the possibility of recovery by hygienic treatment, one would be inclined to desist from so severe an interference as this operation with its uncertain results. One cannot operate in the healthy tissue, and there is danger that the interference may infect other portions of the body with bacilli.

Cavities of the lung have been the subject of operative interference more frequently, although the results are hardly better. Only 1 out of 27 cases reported by Tuffier in 1897 recovered completely. All 6 of Runeberg's cases died, and 13 of Loppez's were unsuccessful, although the operation itself could not be blamed for the fatal result. On the contrary, in the majority of cases, there was temporary improvement after operation. After opening the cavity and treating the same locally the general condition improved, the temperature fell, the cough diminished, and bacilli were no longer found in the sputum. The value of the operation was analogous to that of opening a bronchiectatic cavity. According to Quincke, extension of tuberculosis is not only favored by an abscess along the blood- and lymph-channels, but also by aspiration of tuberculous secretion from the air-passages, and when the size of any of these cavities which act as incubators for enormous numbers of bacilli is diminished, the danger of infection is considerably diminished for the patient.

The author considers that operative interference is indicated when the cavity is isolated and can be fairly well localized, and when the stagnation of the contents produces severe symptoms.

Quincke recommended in 1888 the resection of ribs and cauterization with zinc chloride for the purpose of forming scar-tissue in the lung without opening the cavity. Spengler recommended in 1890 a thoracoplastic operation without opening the pleural cavity. Quincke reported 2 cases in 1896, and considers that resection of ribs should be performed because it is less damaging and because it furnishes the condition which favors spontaneous recovery from tuberculosis of an apex.

It has been mentioned that there are two mechanical reasons which interfere with the healing of cavities in the lung: first, stagnation of secretion, and, second, adhesions between the lung and the chest-wall. Experience and daily observation have taught the author that tuberculosis of the lung may be especially vicious in well-developed individuals, probably because the unyielding upper portion of the chest favors the formation of cavities. The author believes that this anatomical peculiarity, by preventing encapsulation and scar-tissue contraction, favors extension of tuberculosis in the lung more than in any other organ. It should be the surgeon's endeavor to overcome this rigidity as much as possible and favor the natural tendency to heal within the chest. The cases are all chronic and the influence of any interference on the expectorate and general condition can be carefully watched, and if necessary the cavity can be opened later. A permanent sinus is hardly avoidable. The selection of proper cases and an accurate diagnosis, and the indications in any individual case, are factors very difficult to determine, and the success of the future will depend upon the harmonious assistance of physicians and surgeons.

ECHINOCOCCUS OF THE LUNG.

The prognosis of this condition is not especially unfavorable from a surgical standpoint. Next to the liver, the lung is most frequently affected by echinococcus. According to Neisser, 7 per cent. of all the cases affect the lungs, and 11.9 per cent. according to Madelung. Echinococcus of the lung is said to be especially common in Australia. In Germany it is prevalent in Mecklenburg and Pomerania. The prevalence of this disease in these regions depends without doubt upon the large number of domestic animals in those countries (sheep and dogs).

Echinococcus develops most often in the lower lobe of the lung, especially on the right side. In Neisser's statistics it was found 25 times on the right side, 12 times on the left side, and only 6 times on both sides. As a rule there is only one cyst. It is rare to note several foci in the lung. The parasite develops as a rule in the parenchyma. The connective-tissue capsule is extremely thin. According to Ahlers, this capsule is not due to an inflammatory process, but owes its existence to changes of the neighboring lung-tissue. The very thin capsule and the yielding nature of the lung-tissue present the most favorable conditions for the growth of echinococcus. The cyst may become extremely large, not infrequently filling the entire pleural cavity, displacing the heart, diaphragm, and neighboring abdominal organs.

Reference has been made to the development of gangrene and abscess of the lung in connection with echinococcus infection. The bronchi are perforated more frequently and the fluid and daughter-cysts are expectorated. Sometimes the cyst perforates into the pleural cavity or ruptures through the chest-wall or through the diaphragm.

Symptoms.—The symptoms depend upon the position of the parasite and its size. Small cysts may remain latent in the lung for a long time. Large tumors produce tension, pain from pressure, and dyspnœa on the slightest exertion. The patients become emaciated, sallow, and have a slimy, blood-tinged, yellowish sputum. No respiratory murmur is heard over the area of dulness. Sometimes there may be faint bronchial breathing or a few small moist râles at the end of inspiration. If the cyst perforates into the bronchi during the attack of coughing, death from suffocation may follow. On the other hand, the physical signs of cavity may appear after the cyst has emptied and complete spontaneous recovery may follow. In rare cases the cyst breaks into the pleura. This condition may be confounded with a tuberculous process, especially if there is present at the same time a dry, irritating cough. After perforation urticaria has been repeatedly observed to develop while absorption was going on. If the cyst communicated with a bronchus, pyopneumothorax may develop, which renders the condition much more severe.

Diagnosis.—The diagnosis is made as a rule only after the cyst has ruptured and small cysts are being cast off, or when exploratory puncture shows characteristic elements. Up to this time the symptoms may be analogous to those of tuberculosis of the lung, which disease can be excluded only by the persistent absence of tubercle bacilli in the sputum. Sometimes echinococcus cysts produce marked bulging of one side of the chest. There will be absolute dulness over the prominent area and marked diminution of physical signs on auscultation. The condition leads one to suspect some intrathoracic growth, the seat of which is supposed to be in the lung itself on account of the bloody sputum, which is hardly ever absent. Malignant new growths and infarctions have been at times confounded with this condition. Although exploratory puncture is to be condemned on general principles, it must be made use of in these cases to differentiate between the cyst and a pleuritic effusion.

Prognosis.—The prognosis is always grave, but not necessarily unfavorable. It has improved considerably since echinococcus of the lung has become the subject of operative interference. The results of lung surgery are nowhere so successful as in this field. Tuffier reports 55 recoveries out of 61 cases. Mosler's and Peiper's statistics, reporting 21 cases not operated upon, show 50 per cent. recoveries. Reclus found in 1895 that about two-thirds of the patients not operated upon died. Freyhan reports 13 cases of echinococcus of the lung. He does not include those cases in which there was secondary empyema or pyopneumothorax, due to rupture of the primary disease into the pleura, so that surgical interference as regards the primary focus is out of the question. These cases do not bear any special relation to pneumotomy proper. The percentage of recovery in the 13 cases was 91. This corresponds, generally speaking, to the statistics of other authors. Maydl reports 9 recoveries out of 10 cases; Thomas, 27 recoveries out of 32 cases, and Schwalbe reports 6 cases with recovery in each. Garrè's statistics show that of 96 cases in which the focus was freely opened and cleaned out 79 recovered and 8 died. These figures prove so conclusively the necessity and justification of pneumotomy that further comment is unnecessary. The author has emphasized that exploratory puncture with subsequent washing out of the cyst is dangerous and no longer advocated. According to Maydl, 10 out of 16 cases treated by aspiration died, and 6 of these as the result of suffocation within twenty-four hours, due to flooding of the bronchi with cyst contents. The other 4 died of empyema.

ACTINOMYCOSIS OF THE LUNG.

Primary actinomycosis of the lung is uncommon. According to Rütimeyer, only 20 per cent. of the cases are primary in this region, whereas the first infection takes place in 50 per cent. of the cases in the mouth and pharynx, and in 15 per cent. of the cases in the stomach and intestinal canal.

Symptoms.—There are a catarrhal superficial variety affecting the air-passages and a destructive inflammatory variety involving the parenchyma of the lung. There are no autopsy reports of the first variety, while the second is much more common, and is characterized by malignant progressive disintegration of the lung-parenchyma. According to Karewski and Israel, there are three stages of destruction.

In the first stage there develop peribronchial and pneumonic foci that form cavities of varying size due to coagulation-necrosis. At the periphery there are reactive inflammation and abundant formation of connective tissue which causes considerable induration and contraction of the lung. The symptoms in the early stages are so slight that usually they do not attract the attention of the physician. The signs of chronic pulmonary disturbance develop slowly and insidiously without manifesting characteristic symptoms, unless perhaps a few actinomycotic fungi are accidentally found in the sputum. When the disease has existed for a considerable time, or when a large portion of the lung has become indurated, the region affected may be detected on percussion and auscultation. The foci, as a rule, do not involve the apex of the lung, but appear below the clavicle laterally and behind.

The symptoms in the second stage of the disease are much more marked. The continually progressing disturbance gradually reaches the surface of the lung and attacks the overlying serous membranes. The pleuræ become adherent or the pleural cavity becomes filled with an acute effusion, or, what is more common, effusion with adhesions progresses simultaneously. The destruction and contraction of the lung-tissue become more and more marked. Large portions of the lung become carnified and obliterated, and the diameter of the thorax becomes less. The simultaneous presence of retraction of the chest and fresh pleurisy with effusion is very suspicious of actinomycosis of the lung. These effusions are frequently the first symptoms that bring the patient to a doctor. The surface of the lung adheres to the chest-wall as the fungus involves the neighboring regions. Thick, fibrous bands and granulation-tissue progressively infiltrate the chest-wall, or burrow downward through the diaphragm and attack the upper surface of the liver or cause peritonitis. In the interior of the thorax the process may extend to the mediastinum and pericardium. Clinically this stage is characterized by rise of temperature, pain, physical signs of disease of the lung, and swelling of the chest-wall, where the ray fungus has penetrated the intercostal spaces and involved the overlying subcutaneous tissue. The swelling gradually increases in dimensions. In the early stages it is extremely dense and hard. Later it softens in places and may even fluctuate, although as a rule there is no great quantity of pus. A soft, flabby granulation-tissue of low vitality develops. Exploratory puncture rarely shows the presence of fluid, although at times it may be possible to find the fungi in a few drops of the slimy pus that is aspirated. If the needle is inserted deeper, it will penetrate thick fibrous bands and hard areas of infiltration. No fluid is found at all, or, instead of pus, a serous or sero-sanguinous exudate is brought to light. Actinomycosis differs from this condition by its very slow and chronic course and the dense elastic infiltration of the thoracic wall, resembling more that of a tumor. This may be so marked that the condition has frequently been confounded with sarcoma. The expectorate is not pathognomonic aside from the fungi which may be found. It is mucopurulent and in clumps, and may contain fresh blood, but does not present elastic fibres.

The third stage is characterized by the formation of sinuses and uncontrollable progression of the disturbance, not only in the interior of the body, but also on the surface. No variety of tissue is immune. Metastases are common and may appear in any organ. The clinical picture of metastatic pyæmia may be present. The condition may persist for years, and death results from defective nutrition on account of the numerous sinuses from complications involving vital organs, or from amyloid degeneration.

Diagnosis.—Primary actinomycosis of the lung usually presents the picture of chronic tuberculosis. With continued fever, night-sweats, dyspnœa, progressive emaciation, and repeated hæmoptysis there will be little doubt as to the diagnosis. The persistent absence of bacilli will aid in making a correct diagnosis. In some cases an early diagnosis of actinomycosis of the lung may be made by examining the sputum microscopically. Of 34 cases reported by Hodenpyl, a correct diagnosis was made 18 times during life; 9 times the fungi were found in the sputum and 9 times in the pus from abscesses of the chest-wall. Further cases have been reported by Powell, Godlee, Taylor, and Crookshank. When examining the sputum the fungi might be confounded with the shreds of leptothrix. These, however, are stiffer and thicker than the actinomycosis fungi, are never branched, and are usually adherent to epithelial cells. The fungus may at times resemble the leucin crystals found in the sputum. Sometimes the clinical picture is that of chronic pyæmia. The presence of fungi will decide the diagnosis in these cases. The points which would enable a differential diagnosis between a new growth and echinococcus cyst have been considered.

Up to the present time 4 cases of actinomycosis of the lung have been reported that were cured by operation: 1 by Karewski, 2 by Schlange, and 1 by Jakowsky. The author agrees with the statement made by Karewski that aside from these 4 cases there are a vast number of cases that succumb with or without operation. The operative interference was limited to opening up sinuses and abscesses, to be sure, and no attempt to remove the disease radically was made. Complete removal of the diseased tissue with a portion of the healthy tissue gives the only prospect of permanent cure. In a certain number of cases actinomycosis will be recognized sufficiently early to be the subject of operative interference. The stage in which the first signs of extension to the chest-wall appear seems to be the most favorable. When there are swelling of the chest in one place and retraction in another, board-like infiltration of the soft parts, signs of pleurisy without effusion, or apparent empyema necessitatis with accumulation of serum, a chronic course, absence of tubercle bacilli or elastic fibres in the sputum, it will be justifiable to make a diagnosis of actinomycosis even when the ray fungi cannot be found. These symptoms demand exploratory puncture with large needles, which may at times furnish the desired evidence. On incision the flabby granulations covered with yellow spots and old hemorrhages in the interior of dense fibrous tissue will indicate the nature of the trouble. The small fungi may be seen during the operation in the vast majority of the cases. This is the time to remove all tissue involved regardless of the soft parts and anatomical relations. In some cases one may be able to save a life which otherwise would have been sacrificed to the disease.

TUMORS OF THE LUNG.

Malignant Growths of the Lung.—**Carcinoma.**—The comparative rarity of cancer of the lung, the indefinite symptoms, and the lack of success attending surgical interference correspond to the slight consideration of this subject in most text-books. Primary cancer of the lung does not seem to be so uncommon as is generally believed. According to Lenhartz, there were 12 cases out of 2956 autopsies. Statistics prepared in Dresden and Munich, including 20,000 and 12,000 autopsies, respectively, showed that primary carcinoma of the lung was present in 2.2 and 0.65 per cent. of the cases. It is much more common in men than women and appears in the advanced years of life. The cancers of the lung are either cylindrical epithelium or squamous epithelium. The former are much more common than the latter. According to Siegert, primary carcinoma of the lung develops first from the alveolar epithelium; second, from the epithelium of the bronchial mucous membrane; and third, from the epithelium of the bronchial mucous glands. Primary endothelial cancer develops from the endothelium of the superficial pleural lymph-channels and from the endothelium of the pulmonary lymph-channels. Tuberculosis and carcinoma have frequently been found present at the same time. Of 31 cases described by K. Wolff, tuberculosis was found in 23. Schwalbe examined 10 primary carcinomata of the lung and found tuberculosis in the lung associated 3 times.

Symptoms and Diagnosis.—Circumscribed tumors, even when they are as large as a hen's egg, rarely produce symptoms that can be detected by auscultation and percussion, because they are usually deep seated and covered by a layer of air-containing tissue. The flat, diffuse variety soon produces symptoms of chronic infiltration of the lung. The presence of bits of tumor in the sputum is the only way of making a positive diagnosis. These may be found in the sputum or in the pleural effusion, or in the material aspirated from the tumor.

Aside from the blood found in the sputum, which does not present anything especially characteristic, Hampeln has described certain cells, the presence of which is said to be more or less indicative of carcinoma. These are polymorphous polygonal cells free from pigment, vary in size, and have a distinct outline and distinct nucleolus. They may be in groups or separated, and giant cells sometimes are found. Particles of the tumor itself make the diagnosis easier. If the fluid removed by exploratory puncture shows a number of polymorphous cells or perhaps groups of cells, it is justifiable to make a diagnosis of malignant tumor. In the majority of cases, however, there will be no pleuritic effusion, because the pleuræ are intimately adherent. It should be remembered that scattered endothelial cells may be found in any pleural effusion, and that the absence of bits of tumor does not necessarily exclude carcinoma. König was able to remove a portion of the tumor by using a large canula for exploratory puncture. Microscopical examination showed the presence of lymph-cells with large nuclei that were surrounded by elastic fibres arranged in bundles. Personally the author prefers not to make use of this method of examination, because it has at times been followed by alarming hemorrhage. Marked dyspnœa and increasing cachexia depend on the extent of the new growth. When the tumor increases in size the area of dulness can be distinctly traced. The respiratory murmur ceases within a very short time. Tuberculosis of the lung, chronic pneumonia, and pleurisy are the only conditions to be mentioned in the differential diagnosis. The Röntgen rays may give valuable information as will be seen later when considering sarcoma. As far as aneurism and tumors are concerned which develop exclusively in the mediastinum, it may be mentioned that all of the above symptoms may be present, in so far as they are due exclusively to pressure in the mediastinum.

PROGNOSIS.—The chief reason why the prognosis is so unfavorable is probably because of the late diagnosis. If it were possible to detect carcinoma in its early stages, the result of treatment might not be any worse than with carcinoma of the stomach. It does not seem unreasonable to perform exploratory thoracotomy just as exploratory laparotomy in cases in which there is sufficient reason to suspect some malignant growth. Pneumectomy is the only means of giving the patient any possible hope for recovery. Up to the present time not a single case has been the subject of operative interference. Weinlechner was first to resect a portion of the lung in a case of myxochondroma of the chest-wall that had extended to the parenchyma. Four out of 8 cases operated upon for tumor of the chest-wall that involved the lung recovered, according to Tuffier's statistics. Of the 4 that died, 2 succumbed shortly after the operation to pleuritis. Helferich's case is worthy of mention because two lobes of the lung were resected and the vessels and bronchi tied near the hilus. This case died, but demonstrated that the operation was possible technically.

Sarcoma.—Primary sarcoma of the lung is much more uncommon than carcinoma. A peculiar primary growth in the lung, which is considered by C. Wagner to be a lymphosarcoma, develops, according to Hesse, endemically in miners in Schneeberg. These tumors appear isolated in the lung in the bronchial mucous membrane or in the peribronchial connective tissue, or in both locations simultaneously. They develop slowly and form nodules that may become of enormous size and involve the glands, the pleura, liver, and spleen. Cohnheim claims that these lymphosarcomata may possibly be due to infection. The author shares the opinion of Auke that the action of the dust is mechanical, because the arsenic which is contained therein has been used with a certain amount of success for the cure of malignant lymphoma.

Microscopically the tumor consists of typical lymphosarcomatous tissue with an abundance of lymph-cells and nests of spindle cells. The remaining primary sarcomata of the lung differ anatomically and clinically from the lymphosarcomata. Spindle-cell sarcomata are most common, while the small and large round-cell sarcomata and mixed varieties are rare. One case of myxosarcoma has been reported. Lymphosarcoma usually infiltrates the entire lung, extending along the bronchi or forming multiple nodules, whereas the other varieties usually develop as one large focus. This may involve an entire lobe or almost the entire lung.

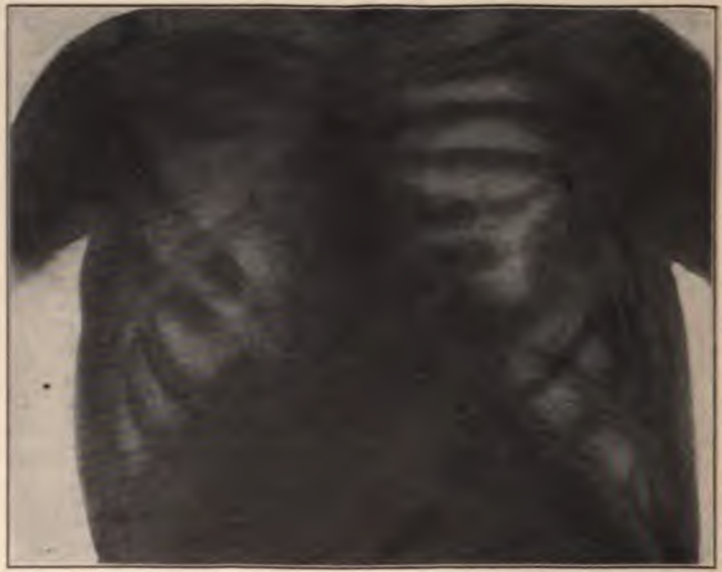
Diagnosis.—The remarks made in connection with the diagnosis of carcinoma apply equally as well to sarcoma. There are apt to be a pain in the side, a sense of oppression, and cough in the early stages. These symptoms are usually supposed to be due to a persistent unilateral or bilateral bronchial catarrh. Schwalbe considers that the stridor is of especial diagnostic value, and claims that its absence in carcinoma is due to the fact that the resonant respiratory murmur is modified less by diffuse intrabronchial interference than by the circumscribed extrabronchial constriction found with sarcoma. He calls attention to the fact that the enlargement of the lymph-glands may be so great as to constrict the large bronchi, whereas in carcinoma the glands are noticeably small. The sputum does not vary materially from ordinary bronchitic expectoration. Characteristic fragments of the tumors have as yet never been found. A. Fränkel called attention to the fact that the frequent occurrence of cells with vacuoles in the serosanguinous pleuritic effusion points to a growth in the thoracic cavity. The area of dulness, of course, becomes larger as the tumor develops. Metastases are much more common in sarcoma than in carcinoma. They appear as a direct involvement of neighboring organs, such as the heart, vessels, and vertebral column, or may be carried to the other lung by the blood or lymph, or infect lymph-glands at some distance, as well as the liver, spleen, kidneys, peritoneum, and brain. Secondary conditions appear in the lungs, such as pneumonia and gangrene, and are apt to terminate fatally within a short time. Fig. 184 shows that the x-rays may be of value in making a diagnosis.

Treatment.—The question of treatment has been considered in connection with carcinoma. In view of the success following excision of carcinomatous portions of the lung in connection with tumors of the chest-wall, it would seem justifiable to attack primary sarcoma of the lung in the early stages. Up to the present time the treatment has been symptomatic.

Benign Tumors of the Lung.—These tumors occur so infrequently that they have not been described clinically or pathologically to any extent. They are usually found on autopsy, and on account of their slight surgical interest only brief mention of the cases reported will be given.

Miliary lymphomata have been observed as occurring in large numbers in the lung in the course of leukæmic and pseudoleukæmic hyperplasia of the lymphatic organs. These small growths are numerous but possess no clinical interest. The same applies to *lipomata*, which are found as smooth round tumors beneath the pleura about the size of a pea. *Fibromata* of the lung have been reported by Rokitansky, Rindfleisch, and others. They were multiple and varied in size from that of mustard-seed up to that of a hazelnut. They were almost always situated immediately around the bronchi, and evidently developed from the peribronchial connective tissue or the connective tissue of the bronchial wall. *Enchondromata* are found in the lung more frequently than in other organs. They develop from the cartilage of the bronchi. They form round irregular masses, the size of a hen's egg, consisting of hyaline cartilage. They are usually found near

FIG. 184.



x-ray of sarcoma of the lung.

the hilus of the lung and are of no clinical importance. *Osteomata* were observed by Luschka. They were small, delicate trabeculæ of bone in the interlobular tissue. The author has a specimen of this sort the size of a fist taken from the lung of a man well advanced in years. *Dermoids* are of more importance. The chief clinical symptom consists of the coughing up of hair. The other symptoms have no differential diagnostic significance. There remain finally to be mentioned *endotheliomata*, which develop in the pleura and extend to the lung.

[illegible] of extensive

[illegible] and gangrene

[illegible] inflammatory proc-

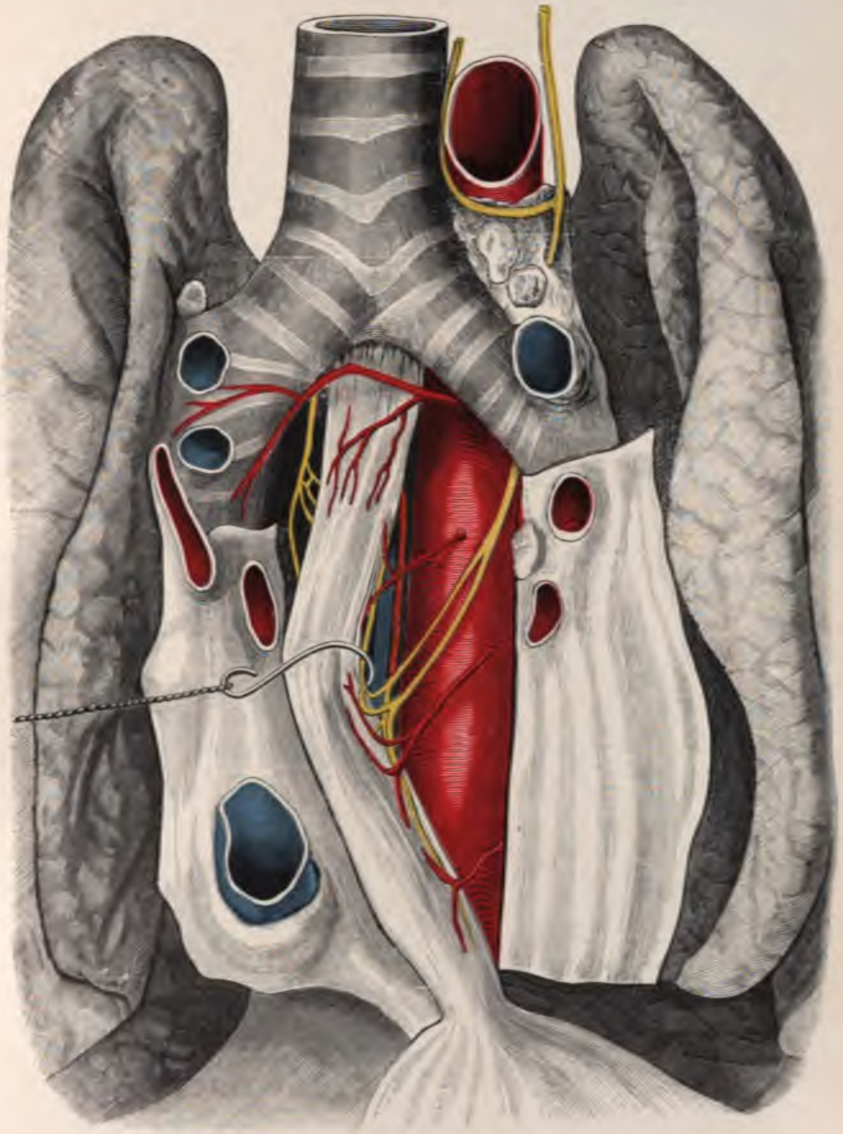
[illegible] the mediastinum.

[illegible] common. Medi-

[illegible]

[illegible] of mediastinitis, whether [illegible] only beginning inflam- [illegible] more marked in the acute than in [illegible] due to some tuberculous process. [illegible] pain in the chronic cases. The pain

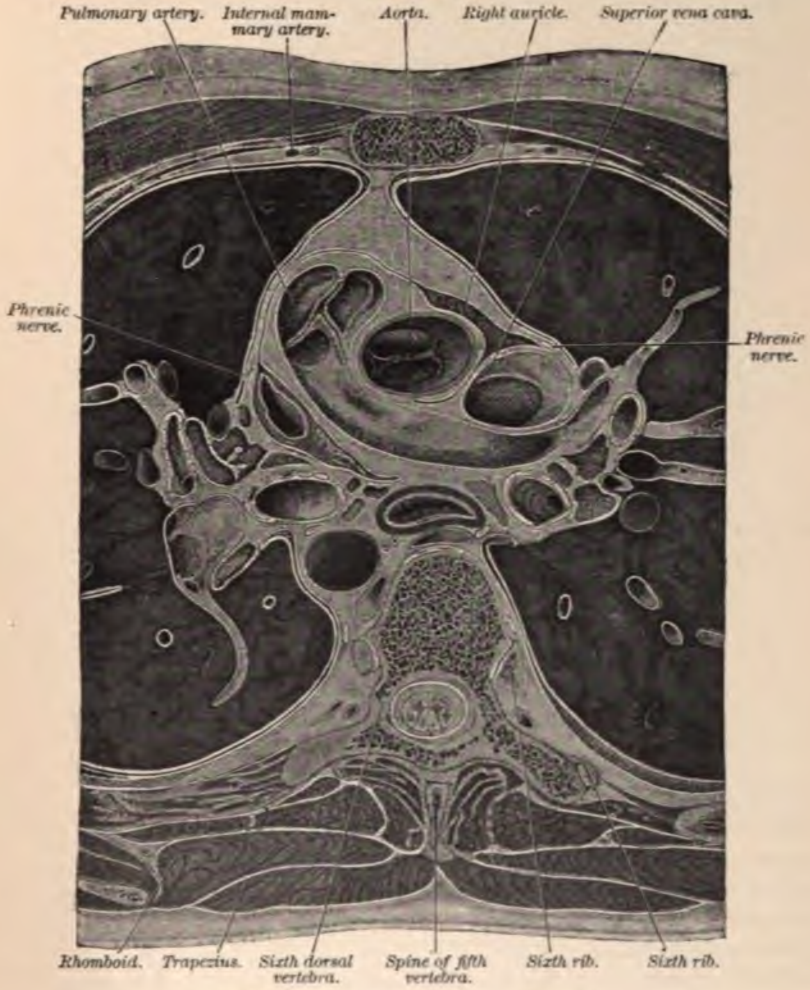
PLATE XV.



Relations of Main Bronchi (anterior view).

is usually situated behind the sternum, radiating to the shoulder-blade and producing at times symptoms referred to the vertebral column. When the suppuration is situated behind the mediastinum, the nerves leaving the spinal canal may be affected, thereby causing pain in the anterior region of the chest, radiating toward the sternum and resembling inflammation of the anterior mediastinum. When the inflammation is in the anterior mediastinum, the sternum may be sensitive to pressure, slightly reddened, and swollen. Not infrequently the pain is influenced by the heart action, so-called pulsating pain. Fever and pain usually appear early. Chills and sweating are frequent. Some-

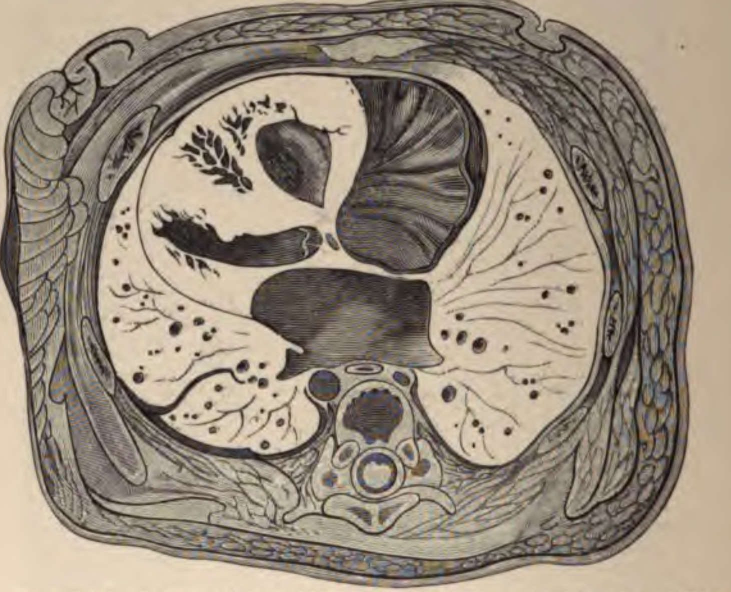
Fig. 185.


Pulmonary artery.
Internal mammary artery.
Aorta.
Right auricle.
Superior vena cava.
Phrenic nerve.
Phrenic nerve.
Rhomboid.
Trapezius.
Sixth dorsal vertebra.
Spine of fifth vertebra.
Sixth rib.
Sixth rib.

Mediastinum, transverse section. (Braune.)

times the process resolves, the inflammatory exudate becomes absorbed, and the fever diminishes. Adhesions and fibrous bands form, which may exert traction upon the neighboring organs and are a source of annoyance for some time. This condition, however, is uncommon. If suppuration has taken place, there will be more or less marked signs of pressure. The patients suffer from dyspnœa, show anxiety, and are restless. The heart action may be irregular or there may be a pulsus paradoxicus. The signs of pressure are never so evident as in the solid tumors to be considered later, because the fluid adapts itself better to the available space. The abscess may rupture externally. Fluctuation can be detected over an intercostal space or at the side of the sternum, or the point of rupture may be at some distance with a tortuous sinus leading to the primary focus. The abscess may become chronic, especially in cases of tuberculous disease of bone and glands. When no operation is performed, the abscess may rupture into the trachea or œsophagus or into the pericardium and pleural cavity, and yet recovery may follow. Most of the cases, however, which do not terminate in this way result fatally.

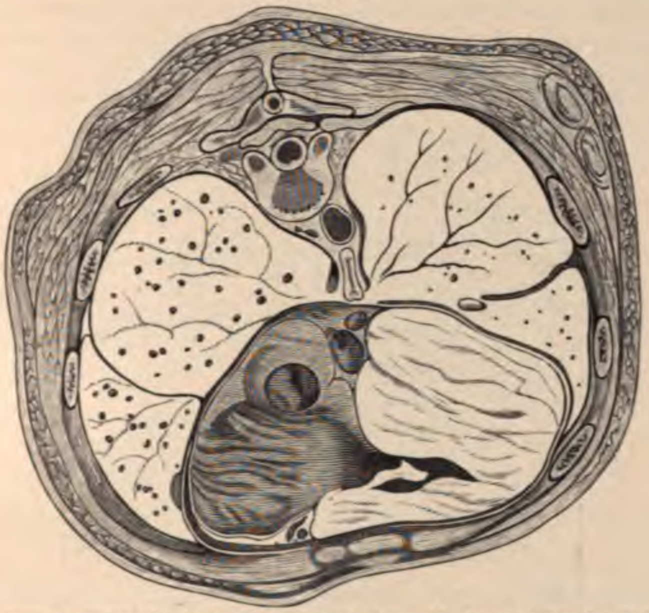
FIG. 186.



Transverse section of chest of infant at birth. Level of upper and sixth dorsal vertebra.

Diagnosis.—When there are present the etiological factors above described, such as disease of the œsophagus, of the trachea, of the vertebral column, or of the sternum or ribs, with fever, pain, and pressure-symptoms, the diagnosis will be comparatively easy. In the early stage there may be difficulty in correctly interpreting the symptoms. When there is local pain or when there are present distinct signs of an abscess tending to rupture externally, there can be no doubt, although it may sometimes be difficult to determine whether the inflammation originated in the anterior or posterior mediastinum. The differential diagnosis between tumors and chronic inflammation without temperature may be difficult.

FIG. 187.



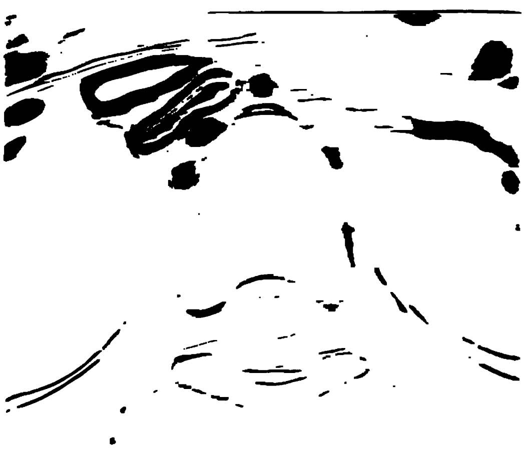
Transverse section of infant at birth at level of seventh or eighth dorsal vertebra.

Prognosis.—The prognosis of mediastinitis is always doubtful. The danger of general sepsis is great, especially in the acute cases and in the metastatic cases, in which there is some severe infectious disease elsewhere. Death from suffocation may follow rupture of the abscess into the trachea. The chronic cases are the most favorable, for it may be possible to palpate the abscess from without and operate sufficiently early.

Treatment.—In the early stages iced or hot compresses should be used to favor absorption or hasten the formation of pus, and an endeavor should be made to drain the abscess cavity as early as possible. The operative interference will vary according to whether the anterior or posterior mediastinum is to be opened.

Galen opened the anterior mediastinum for the purpose of draining an abscess. He trephined the sternum of a young man with success. This operation has been performed recently many times. When the abscess points externally at the side of the sternum, one should make the incision in this region, and after introducing a finger enlarge the opening and resect as much of the ribs and sternum in

[illegible]

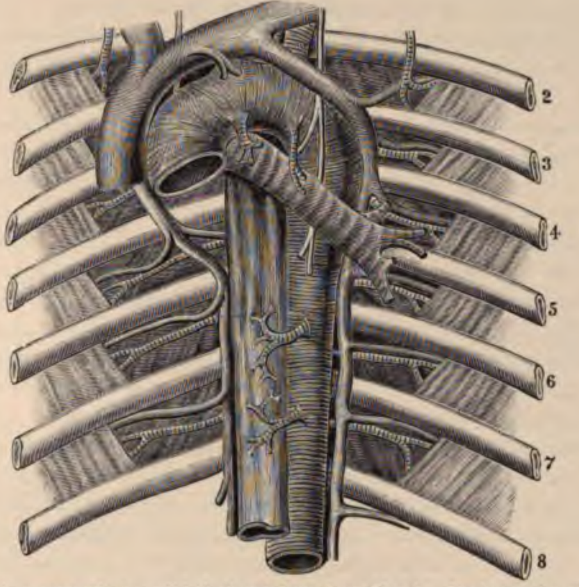


[illegible]

[illegible] was reported in 1888 [illegible] M[illegible] in 1893 [illegible] reported 5 cases [illegible]. Thirteen cases have been [illegible] inflammatory processes. [illegible] in connection with caries of the [illegible]

[illegible] point as a rule in the supraclavicular fossa. Heidenhain opened in the supraclavicular fossa an abscess which had been produced by a foreign body in the œsophagus, causing suppurative mediastinitis. A curved incision was made over the right clavicle and necrotic connective tissue found by dissecting downward. The wound was packed with iodoform gauze and recovery took place. Cavazzani reports a similar favorable case.

FIG. 189.



This figure is a somewhat modified view taken from Morris. It shows the relation of the œsophagus to the aorta below the arch, the intercostal vessels, and the venæ azygos, and the relation of each to the ribs, intercostal tissues, œsophagus, etc. (Bryant.)

When the conditions are such that the seat of operation is not indicated, the posterior mediastinum must be approached from behind. Heidenhain showed by post-mortem experiments that by resecting the transverse process and the adjoining piece of rib the posterior mediastinum could be sufficiently opened. The skin-incision is made close to the median line, and if necessary a second transverse incision may be added, dividing the skin and muscles. This method is well adapted for opening the upper portion of the posterior mediastinum. When the inflammatory process is in the lower portion, where the aorta and œsophagus may be interposed between the focus and the vertebral column, the conditions are much more difficult. Heidenhain's suggestion may be followed in these cases and several transverse processes resected with the adjoining ribs. In this way the cavity may be opened up sufficiently and the œsophagus exposed, which is so frequently the source of inflammation. This method is associated with much less danger to the pleura than the method advocated by Quénu, Hartmann, Rehn, and others, who resect the ribs much more to one side. Considerable discussion has arisen over the question whether the right or the left side should be attacked. When the exploratory puncture indicates that most of the pus is on the left side, the author prefers to operate in this region. In other cases he prefers the right side for anatomical reasons.

TUMORS OF THE MEDIASTINUM.

Primary Tumors of the Mediastinum.—**Etiology.**—The etiology of tumors of the mediastinum is no better known than that of growths in other portions of the body. It is not probable that trauma plays any part.

Symptoms.—The first symptoms of tumors of the mediastinum are connected with the lung. Pressure-symptoms appear within a short time, because the growth progressively limits the space within the chest and interferes with the thoracic viscera. This applies to benign as well as to malignant growths, although the latter are more likely to be productive of more vicious symptoms on account of their quick growth and rapid invasion of the viscera. Bulging of the chest-wall, either of the ribs, the clavicle, or of the sternum, is a late symptom which facilitates the diagnosis considerably. Malignant tumors invade the viscera, penetrate the bony wall, and appear externally as tumors of varying size covered only by the soft parts and skin. The tumors may extend upward and involve the supraclavicular fossa.

Sometimes the tumor mass may be observed to pulsate distinctly. This may be due to the great vascularity or because the heart impulse is transmitted. The veins on the anterior and lateral portions of the chest are apt to be distended, or there may be circumscribed œdema over the sternum or over some other portion of the chest or shoulder. One should always palpate the neck. The larynx may be perfectly immobile. The trachea may be displaced and enlarged lymph-glands in the neck and axilla will be of great diagnostic importance. Sometimes it is possible to introduce a finger behind the upper margin of the sternum and palpate the upper portion of the tumor.

Tumors which lie in contact with the sternum may be easily detected on percussion, and any displacement of the normal lines will be evident. Dyspnœa is a prominent symptom of tumors of the mediastinum. This may be produced by pressure upon the trachea, recognized by difficult inspiration and stridor, or the lungs and bronchi may be compressed as well as the heart and large vessels. No conclusions are to be drawn from the cough or expectoration which is usually associated with disturbances of respiration ; neither does hæmoptysis aid the diagnosis materially.

Pressure upon nerves is common. Sometimes the recurrent laryngeal nerves will be involved, causing paralysis of the vocal cords. This is an important symptom, but in the early stages can only be recognized by means of the laryngeal mirror. The paralyzed vocal cord will be in the well-known cadaver position. When the paralysis is bilateral, the dyspnœa may be marked. Pressure upon the vagi retards the pulse in the early stages and causes palpitation later. Gagging, vomiting, and other symptoms have been supposed to be due to pressure upon this nerve.

Course.—The course of the disease varies. Benign tumors grow slowly and may annoy the patient for years, whereas malignant tumors are apt to terminate fatally much more rapidly. Sudden death, even before a diagnosis is made, has been repeatedly observed.

Diagnosis.—It is often impossible and frequently difficult to make a diagnosis of tumor of the mediastinum in the early stages. The above-described symptoms, one or the other of which will be more or less marked, will eventually lead to correct conclusions. Lately, the Röntgen rays have been used with success for purposes of diagnosis. When the tumor is of any size, the shadow may be well outlined and is usually evident on both sides of the sternum.

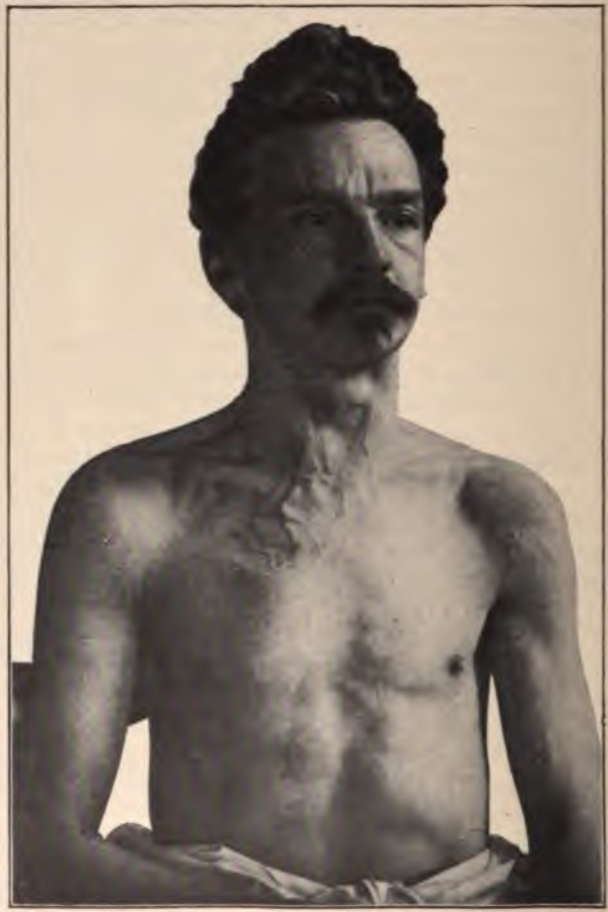
It is sometimes difficult to differentiate tumors from aneurisms of the aorta which are situated in the mediastinal space and that have symptoms in common with the new growths. The symptoms indicative of disease of the vessels, aortic insufficiency, etc., should attract especial attention. Signs of inflammation will predominate in mediastinitis and prevent confounding with tumors. Pleurisy, pericarditis, and infiltration of the lung-tissue will seldom be confounded with new growths. It is always important to determine the nature of the tumor because the prognosis and treatment will depend upon accurate information in this direction.

Benign Tumors.—Barety and Wiederhofer carefully studied diseases of the lymphatic glands. They have subdivided the glands into parietal and visceral, the former being situated along the chest-wall, while the latter are located around the trachea and bronchi and may be deep or superficial. These glands may become enlarged and give rise to extensive tumors in the course of acute infectious diseases or tuberculosis and in conditions associated with secondary infection of glands. The enlargement may resolve spontaneously, soften and break down, or become indurated with deposits of calcareous material. Surgical interference is indicated only in exceptional cases.

There are few benign tumors compared with the number of malignant growths. Lipomata have been reported only a few times. v. Langenbeck reports a case of this sort, and a further observation has been added by Gussenbauer. Fibromata are also uncommon and have not been accurately described. Hoffmann collated 7 cases, only 2 of which are to be considered true fibroma. Eckehorn and Pflanz have recently directed their attention to dermoid cysts. Twenty-six cases have been reported thus far. One of Eckehorn's cases was in a man twenty-eight years of age who had suffered from pleurisy with effusion. This disappeared after an attack of coughing and after expectorating a peculiar looking material. The diagnosis of dermoid cyst of the pleura was made, although the autopsy showed that the anterior mediastinum had been affected, and that there were adhesions with the surrounding organs and a perforation into a bronchus.

Cysts are usually found in the upper section of the anterior mediastinum immediately beneath the manubrium. They vary in size from that of a pigeon's egg to the size of a child's head or larger. According to the investigations of Pflanz, dermoids of the mediastinum are not necessarily derived from the thymus—that is, from the third branchial cleft. They develop slowly and may produce no symptoms, so that a tumor the size of a child's head may be found on autopsy which produced during life no symptoms whatever. Six of the cases reported were operated upon with varying success. Echinococcus of the mediastinum appears to be rare. Hoffmann mentions 4 cases, which are, however, not beyond criticism. Endothoracic goitre, which must be considered a tumor of the mediastinum, has been considered elsewhere.

FIG. 190.



Carcinoma of the mediastinum. (Curschmann.)

Malignant Tumors.—Most of the new growths in the mediastinum are carcinoma or sarcoma. They usually develop in the bronchial glands, although a certain number may arise from remnants of the thymus. The peribronchial connective tissue at the root of the lung has been supposed to be the original seat in certain cases. In the cases reported it is frequently difficult to determine whether the growth was sarcoma or carcinoma. Pronounced lymphosarcoma and true carcinoma have been recorded, which appear to have developed from the bronchi. The carcinomata seem to remain small and circumscribed and produce but few symptoms for a considerable time, whereas the lymphosarcomata are apt to reach considerable size quickly. Hoffmann has reported a distinct group of 11 cases of carcinoma of the large bronchi. Cancer of the bronchial glands is closely related to these, and clinically the tumors can hardly be distinguished because the symptoms are, generally speaking, alike, and, as has been mentioned, it may be difficult to distinguish the neoplasm from benign growths.

Secondary Tumors of the Mediastinum.—**Symptoms.**—The symptoms in the course of secondary new growths in the mediastinum do not differ materially from those of the primary variety. It makes clinically no difference whether there is a primary tumor of the lung or of the pleura or of the chest-wall which has invaded the mediastinum and given rise to symptoms in this connection. Consideration has been given to tumors of the pleura, of the lung, and of the chest-wall, with their symptoms, and the relatively common secondary mediastinal tumors that owe their origin to the mammary gland and have involved the pleura and mediastinal glands later. There may be marked enlargement of the mediastinal glands in Hodgkin's disease and leukæmia.

Prognosis.—The prognosis of mediastinal tumors is generally poor, because the diagnosis is rarely made in the early stages, when the operative chances are most favorable. The prognosis of benign tumors is better, of course. They are usually situated in the anterior mediastinum, and recovery may follow operative interference, as the author's experience with dermoid cysts has demonstrated.

Treatment.—Aside from the administration of arsenic and potassium iodide, which is undoubtedly of value in lymphoma, sarcoma, gumma, and in the general treatment of tuberculous disease of the glands, the main efforts will be of a surgical nature. It depends upon the time that a diagnosis is made whether anything is to be achieved by operation in malignant growths. The surgeon should endeavor to attack these as early as possible. The author is of the opinion that one should proceed as radically as possible the moment the diagnosis is made, resect the sternum, or open the posterior mediastinum and make an effort to save the otherwise doomed individual. In benign tumors which may cause death if not removed, one should operate immediately provided the growth has not progressed beyond surgical aid.

The technic of the operation has been given in connection with mediastinitis. In tumors it will be necessary to open up freely the anterior or posterior mediastinum. The operation is by no means devoid of danger on account of the anatomical relations and the adhesions between large vessels, nerves, the pleura, and pericardium. One will be obliged to resect a portion of the bony chest-wall, including the sternum and adjoining ribs. Whenever the pleura is opened, which can hardly be avoided, it should be closed and the wound packed if necessary. It is probably always best to perform the operation in two or more steps, so as to have the pleura closed and avoid too profuse hemorrhage.

SYPHILIS OF THE MEDIASTINUM.

Syphilis of the mediastinum is comparatively rare. A case of marked enlargement of the bronchial glands due to syphilis has been reported by Weber. A large syphilitic tumor pressing upon the trachea, aorta, and vena cava, was reported by Werner. Küster excised a syphilitic mass that showed no sharp line of demarcation after resection of the sternum and ribs. This was intimately adherent to the pleura and pericardium. Several other similar cases have been reported.

EMPHYSEMA OF THE MEDIASTINUM.

This condition has been observed in connection with trauma, injuries of the œsophagus, diseases of the pharynx, larynx, trachea, and lungs, whenever the continuity of the respiratory organs has been dissolved, so that air is allowed to enter the cellular tissue of the mediastinum. Emphysema appears at the root of the neck and in other portions of the chest; the cardiac area of dulness may be obliterated and the heart sounds masked by a fine moist crackling synchronous with the apex-beat. There may be difficulty in breathing and swallowing. If the cause of this emphysema is not some alarming condition, the air may be absorbed and cause no further symptoms. No especial treatment is necessary except when the symptoms are so severe as to necessitate treatment of the primary cause.

HEMORRHAGE INTO THE MEDIASTINUM.

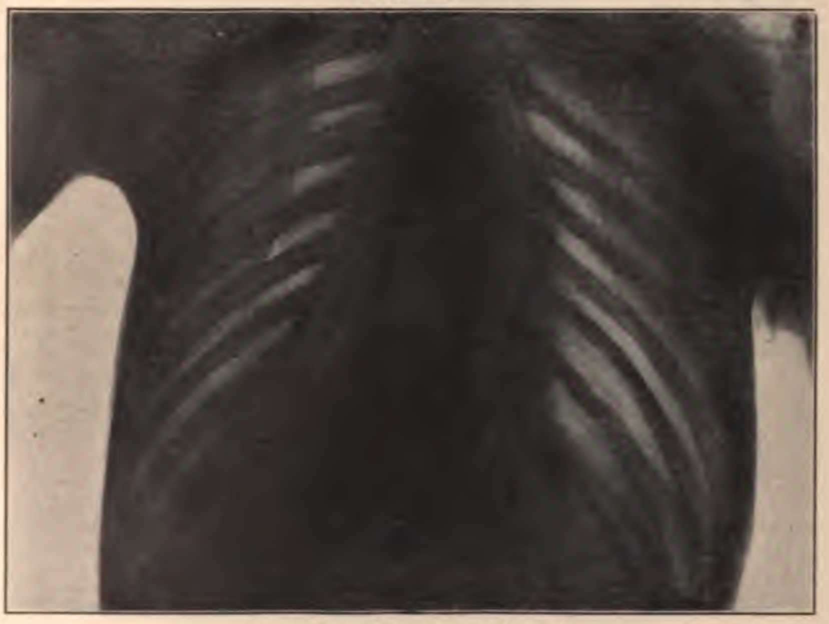
This condition is usually due to trauma on account of injury to the viscera, and is a secondary phenomenon.

CHAPTER XVI.

ANEURISMS OF THE THORACIC AORTA.

Aneurisms of the thoracic aorta belong, properly speaking, to the realm of internal medicine, and will be considered in this connection only on account of the surgical treatment at times advocated. The author will not consider the symptoms, the course, or the diagnosis. He has already touched upon the differential diagnosis in connection with other conditions in the mediastinum, and will mention in this connection only the great advantage of the use of Röntgen rays. A large pulsating shadow can frequently be observed with this means, and Fig. 191 represents an aneurism of the aorta that could be detected in this way, but where the diagnosis clinically was beyond question. Aside from the internal treatment and the regulation of life proper in the medical management of aneurisms of the aorta, there are two special forms of treatment, one of which is directed to the wall of the vessel and the other to the contents of the sac.

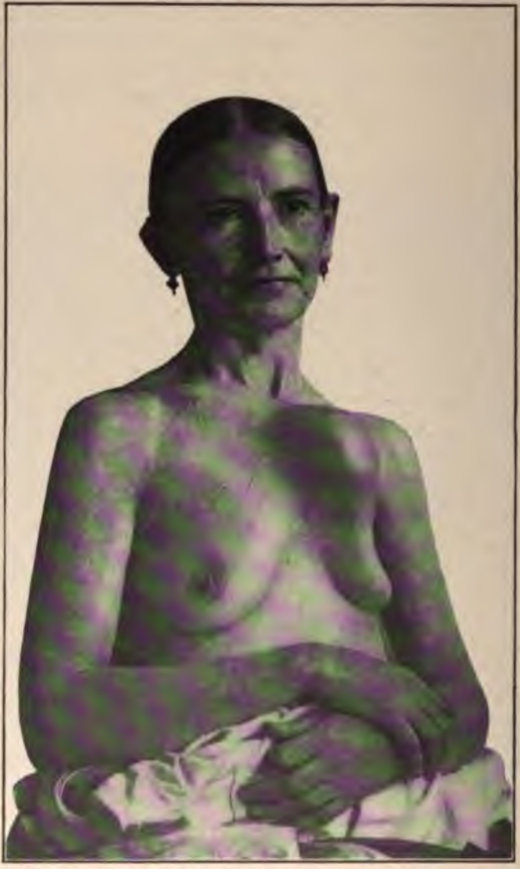
Fig. 191.



x-ray picture of aneurism of the aorta.

Treatment of the Vessel-wall.—Although considerable advance has been made of late in the treatment of affections of the vascular system, the results of direct interference in cases of aneurisms are still doubtful in view of the difficulty in making an early diagnosis, the inaccessibility of the tumor, the proximity of the heart, and the increased blood-pressure. It is not technically impossible to remove a sacculated aneurism. If it is detected early, the wound in the vessel can be closed with a suture. There is no way of influencing and removing the sclerosis of the arterial wall.

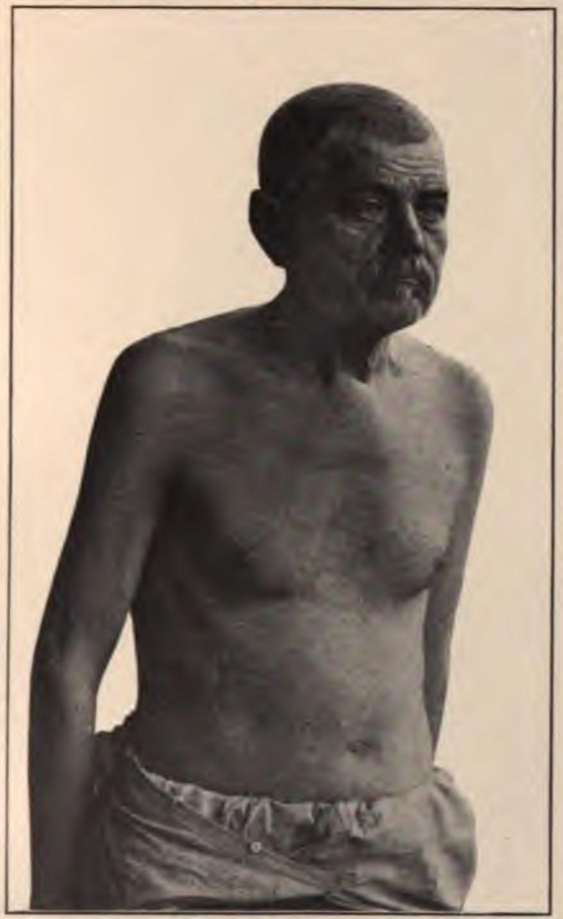
FIG. 192.



Aneurism of the arch of the aorta. (Curschmann.)

Treatment of the Sac Contents.—Coagulation with subsequent thrombus formation may take place spontaneously in the aneurism on account of the slow flow of blood and roughened wall of the vessel. A portion of the sac may be completely filled and the thrombus may become organized and contract, and recovery take place, which, however, means only temporary respite. Those aneurisms having only a small opening are most favorable in this respect. Aneurisms supposed to be syphilitic frequently present this condition, so that the prognosis in these is apt to be more favorable. Cylindrical aneurisms are theoretically not influenced by any sort of treatment. A thrombus in these cases would be a distinct danger to life.

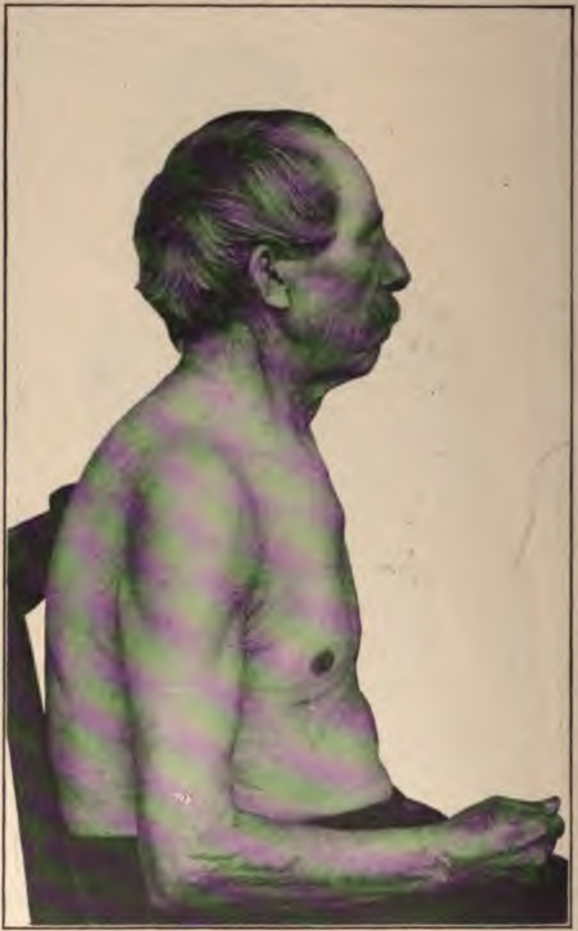
FIG. 193.



Aneurism of the arch of the aorta. (Curschmann.)

All of the methods which have been used endeavor to produce coagulation in the sac or favor this process. A number of the methods advocated are simply theoretical considerations of individuals which, fortunately for the patient, cannot be made use of practically, or, even when this is possible, do not give the desired result. Of these methods there may be mentioned injections of ferric chloride into the sac, puncture with red-hot needles, and galvanopuncture with silver and gold needles. The author made use of this latter method in two cases. The aneurisms were large and presented as pulsating tumors beneath the skin, and had already absorbed the sternum. Puncture was performed at several sittings and no special disadvantage was noted in this connection. There was only slight pain and no hemorrhage if the needle was heated slowly and removed carefully. There was no especial success in either case, for both died suddenly later from rupture of the sac.

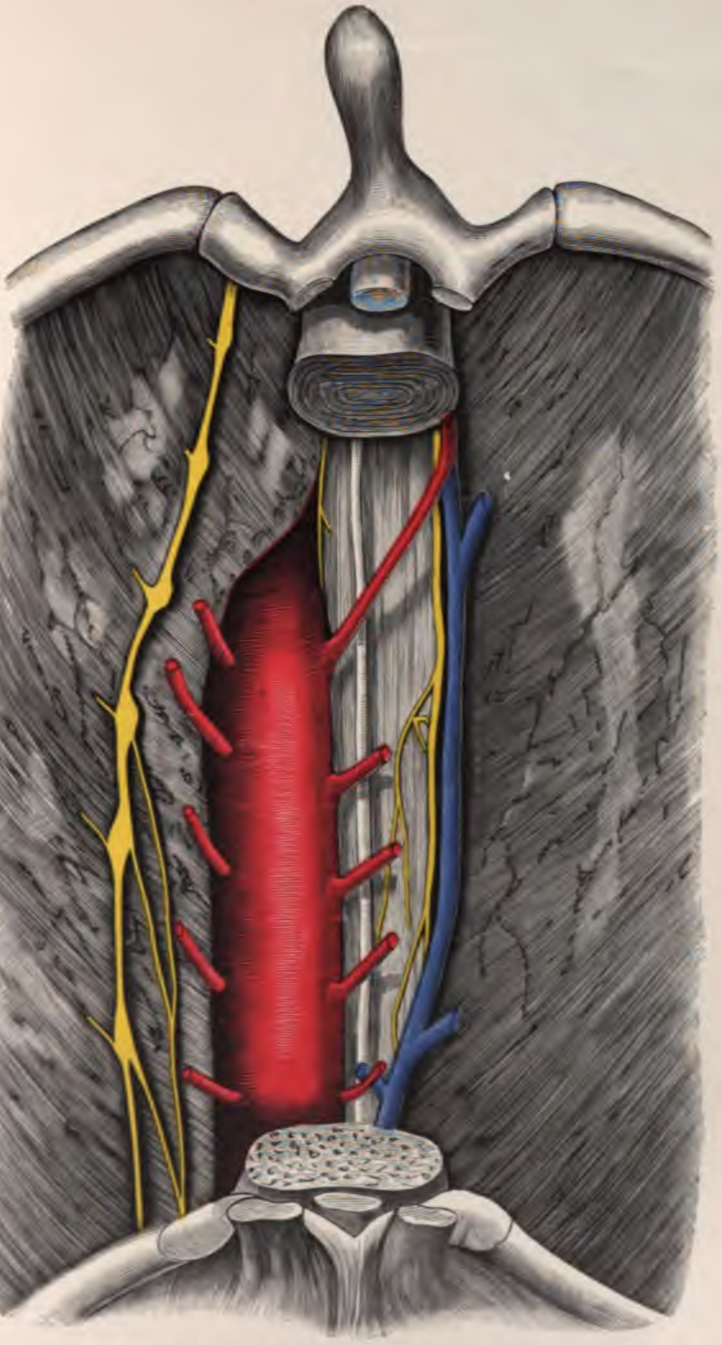
FIG. 194.



Aneurism of the innominate artery. (Curschmann.)

There remains to be mentioned the introduction of foreign bodies into the sac, such as wire, watch-springs, horse-hair, and threads soaked in ferric chloride. Macewen scratches the intima of the sac with a needle, which is supposed to favor the formation of a white thrombus. Brasdor's operation is practical and sometimes successful. In aneurisms

PLATE XVI.



Relations of Thoracic Aorta.

of the ascending aorta and innominate the large vessels of the neck and arm are tied, so that the flow of blood becomes slower. It must be assumed in successful cases that the anatomical conditions are extremely favorable, so that thrombus formation takes place easily when the blood-current is slow. Perhaps the thrombus may form in connection with the plug at the central end of the ligated vessels. When the anatomical conditions are unfavorable, which cannot be determined during life, the operation will not be successful. v. Bergmann and others have successfully performed Brasdor's operation. Curschmann noted distinct although temporary improvement after tying the carotid. The author has personally performed this operation. One of the cases died, and in another the carotid and subclavian on one side were tied, followed by distinct improvement, so that the patient was again able to follow his occupation as a sailor. The subsequent history of this case is unknown. Le Dentu reports 2 cases, 1 of which was successful. Poiret collected 55 cases, 28 of which recovered, 6 were cured, and 22 improved. Of late years Lancereaux and Tanlesco have recommended subcutaneous injections of a 2 per cent. solution of gelatin for the purpose of coagulating the blood in aneurisms of the aorta. These attempts are based upon the animal experiments of Dastre and Floresco, who claim that subcutaneous injections of solutions of gelatin favor coagulation of the blood in the vessels. This statement has been corroborated by Gley experimentally. The action is supposed to be due to the gelatin becoming actually dissolved and carried in solution, not in suspension, by the lymphatics into the blood-current, and favoring in this way coagulation in places where the intima has been pathologically changed. Lancereaux considers that direct injection into the sac, as recommended by other authors, is dangerous. Although much may be said against the use of gelatin injection theoretically, it has been used more or less extensively in Germany, even as a hæmostatic measure in other diseases. Curschmann reports 14 cases of hemorrhage from the lungs, stomach, and intestines treated in this way. In 13 of these the hemorrhage ceased rapidly. Huchard made use of gelatin injections in a case of aneurism of the aorta. The first injection of 1500 c.c. was followed by a rise of temperature to 38.8° C. This injection was repeated three times a week. After the fifth injection pulsation diminished, and after the sixteenth injection an abscess formed at the seat of puncture which resulted fatally. On autopsy the aneurism was shown to be almost completely filled with coagulated blood. This case illustrates the coagulating action of the gelatin and the great dangers connected with its use. Beck (New York) treated the aneurism of the aorta depicted in Fig. 195 with gelatin injections in the vicinity of the sac, made at intervals of four days. The treatment lasted two months. There were no disagreeable secondary symptoms except a slight amount of fever. The patient improved subjectively, but objectively the tumor did not decrease in size, as shown by repeated examinations with the Röntgen rays. The gelatin is prepared in the following manner: 15 grains of white mediastinitis. In tumors it will be necessary to open up freely the anterior or posterior mediastinum. The operation is by no means devoid of danger on account of the anatomical relations and the adhesions between large vessels, nerves, the pleura, and pericardium. One will be obliged to resect a portion of the bony chest-wall, including the sternum and adjoining ribs. Whenever the pleura is opened, which can hardly be avoided, it should be closed and the wound packed if necessary. It is probably always best to perform the operation in two or more steps, so as to have the pleura closed and avoid too profuse hemorrhage.

SYPHILIS OF THE MEDIASTINUM.

Syphilis of the mediastinum is comparatively rare. A case of marked enlargement of the bronchial glands due to syphilis has been reported by Weber. A large syphilitic tumor pressing upon the trachea, aorta, and vena cava, was reported by Werner. Küster excised a syphilitic mass that showed no sharp line of demarcation after resection of the sternum and ribs. This was intimately adherent to the pleura and pericardium. Several other similar cases have been reported.

EMPHYSEMA OF THE MEDIASTINUM.

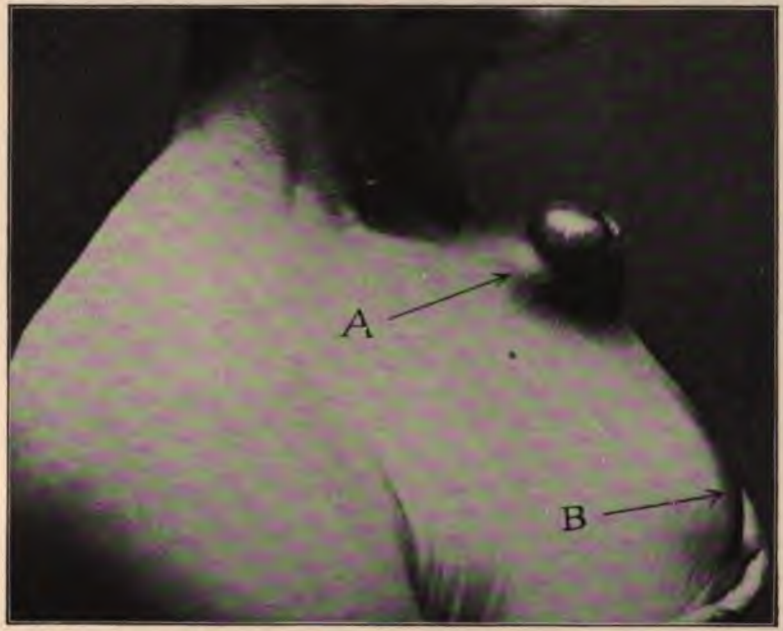
This condition has been observed in connection with trauma, injuries of the œsophagus, diseases of the pharynx, larynx, trachea, and lungs, whenever the continuity of the respiratory organs has been dissolved, so that air is allowed to enter the cellular tissue of the mediastinum. Emphysema appears at the root of the neck and in other portions of the chest; the cardiac area of dulness may be obliterated and the heart sounds masked by a fine moist crackling synchronous with the apex-beat. There may be difficulty in breathing and swallowing. If the cause of this emphysema is not some alarming condition, the air may be absorbed and cause no further symptoms. No especial treatment is necessary except when the symptoms are so severe as to necessitate treatment of the primary cause.

HEMORRHAGE INTO THE MEDIASTINUM.

This condition is usually due to trauma on account of injury to the viscera, and is a secondary phenomenon.

applied. When there is marked disturbance of respiration it may be necessary to perform tracheotomy and use a long canula. König's jointed canula is well adapted to these cases. Success will depend upon the seat of the aneurism, although tracheotomy often does not give relief. When the sac ruptures externally, it should be packed tightly and a pressure-bandage applied, and the packing held in place by several stitches through the skin if necessary.

Fig. 196.



Thoracic aneurism presenting intermittently through the sternum: *A*, tumor before rupture; *B*, position of the lower swelling. (Calot.)

CHAPTER XVII.

SURGICAL DISEASES OF THE PERICARDIUM AND HEART.

THE diseases of the pericardium which may demand operative interference are hemorrhagic, serous, and purulent effusions. Hemorrhagic effusion into the pericardium is usually the result of injury, and has been considered in this connection. A sanguinous effusion has been observed to occur with tuberculosis and malignant new growths. In these cases removal of the effusion is, of course, only a palliative measure. A hemorrhagic effusion is frequently observed in scurvy. Serous pericarditis may be acute or chronic. It is usually caused by disturbances of the circulation, and is associated with effusions into the pleura or abdominal cavity, or is of inflammatory origin and secondary to some acute infectious disease (acute articular rheumatism, typhoid, pneumonia, etc.). The most common cause of chronic serous pericarditis is tuberculosis.

Purulent Pericarditis.—The effusion may become purulent after having existed for some time or is purulent at first. Aside from the traumatic effusions of blood that suppurate, infectious diseases are the chief cause of purulent pericarditis. Besides typhoid, acute articular rheumatism, pneumonia, scarlet fever, and acute osteomyelitis may be associated with this grave complication. Just as in the case of empyema, aspiration of a purulent pericarditis is to be condemned for the reasons mentioned in connection with empyema.

In a boy five years of age, with severe osteomyelitis purulent pericarditis developed, which became evident because of increased dulness and progressive weakening of the heart-sounds. Exploratory puncture showed a purulent effusion. The pericardium was freely opened after resecting the fifth left costal cartilage and 7500 c.c. of pus were removed. The relief was immediate and the temperature fell. The patient died later of secondary osteomyelitic processes.

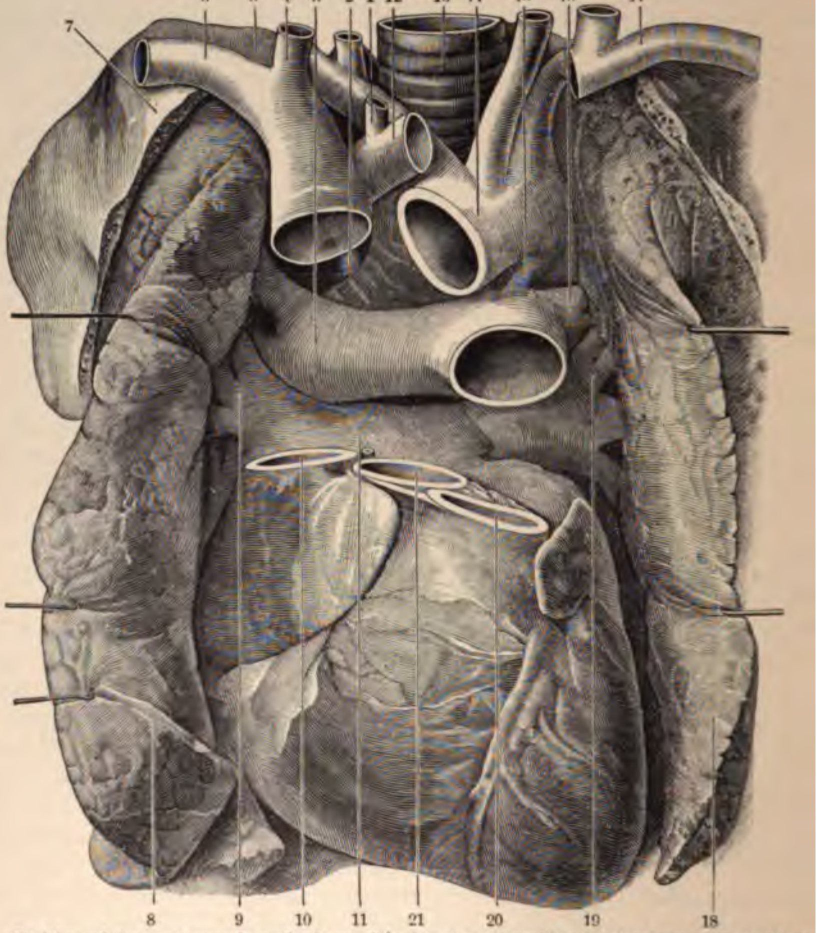
OPERATIONS UPON PERICARDIAL EFFUSIONS.

Indications.—The chief indication for operation is the marked dyspnœa produced by the fluid. This symptom may be present in primary or secondary pericarditis, and the act of opening the pericardium may in certain instances be a life-saving step. Two methods of operation are to be considered: puncture and open incision of the pericardium with resection of a portion of one or more ribs. In hemorrhagic pericarditis with marked signs of pressure, the relief obtained by aspiration may be sufficient, and an open incision can be made later if necessary. In effusions due to disturbances of the circulation and in connection with tuberculosis and carcinoma, aspiration will give temporary relief, but must be repeated frequently. When aspiration does not relieve the symptoms, an open incision becomes necessary, although it will be necessary to resect ribs at the start only in a limited number of cases. All acute serous effusions secondary to the infectious diseases above mentioned, as well as the subacute and chronic effusions, should be treated by aspiration, which may be repeated if necessary. Purulent effusions should be treated by open incision, resection of the costal cartilage, and drainage. Only in very weak patients is it necessary to make use of aspiration as a preliminary operation, so as to relieve the compressed heart without extensive operative interference. Verdelli recommends Riva's aspiratio lavatore. The pericardium is punctured and the cavity washed out with boric acid solution, which may be followed by temporary improvement in mild cases. In the author's opinion, when this method has failed once it should not be repeated, and the pericardium should be freely opened.

Operative Technic.—PUNCTURE OF THE PERICARDIUM.—It is not possible to state just at what moment paracentesis should be performed. Aspiration should always be done when the dyspnœa has become marked and other methods favoring absorption have proved useless. The seat of puncture has been the subject of much discussion. The author believes that it is impossible to state that there is any point applicable to all cases. One should be guided by the conditions present and consider the outline of the area of dulness. The pleura is displaced when the pericardium is distended, so that aspiration may be performed in various places without injuring this membrane. Fig. 198 illustrates the various points that have been made use of for paracentesis. The free pericardium is more apt to be reached close to the margin of the sternum between the fifth and sixth costal cartilages. One should enter the needle close to the sternum or about 3 cm. outside, so as to avoid injuring the internal mammary artery. A trocar is the instrument best used; a rubber may be attached around its end so as to avoid the entrance of air. It is evident that the skin must be carefully cleansed, and the instruments sterilized. The trocar or hollow needle should be introduced inward and upward, and not too rapidly, so as to avoid injuring the heart. One is frequently able to detect the moment the heart is touched with the needle, which should be gradually drawn out as the fluid is removed. The author has repeatedly felt a rubbing against the needle and noted that this took place at the same time as the heart-beat. With care one can avoid injuring the heart or perforating the right ventricle. The fatal cases reported were probably due to too forceful introduction of the needle or to faulty diagnosis. There may have been no exudate whatever, but marked hypertrophy of the heart itself. One should always aspirate with a fine needle before operation.

After introducing the instrument the effusion may be allowed to flow out or may be sucked out with an aspirator. Complicated apparatus should not be used. Many recoveries have followed aspiration and Délorme and Mignon collected 82 cases of aspiration of the pericardium with 28 recoveries.

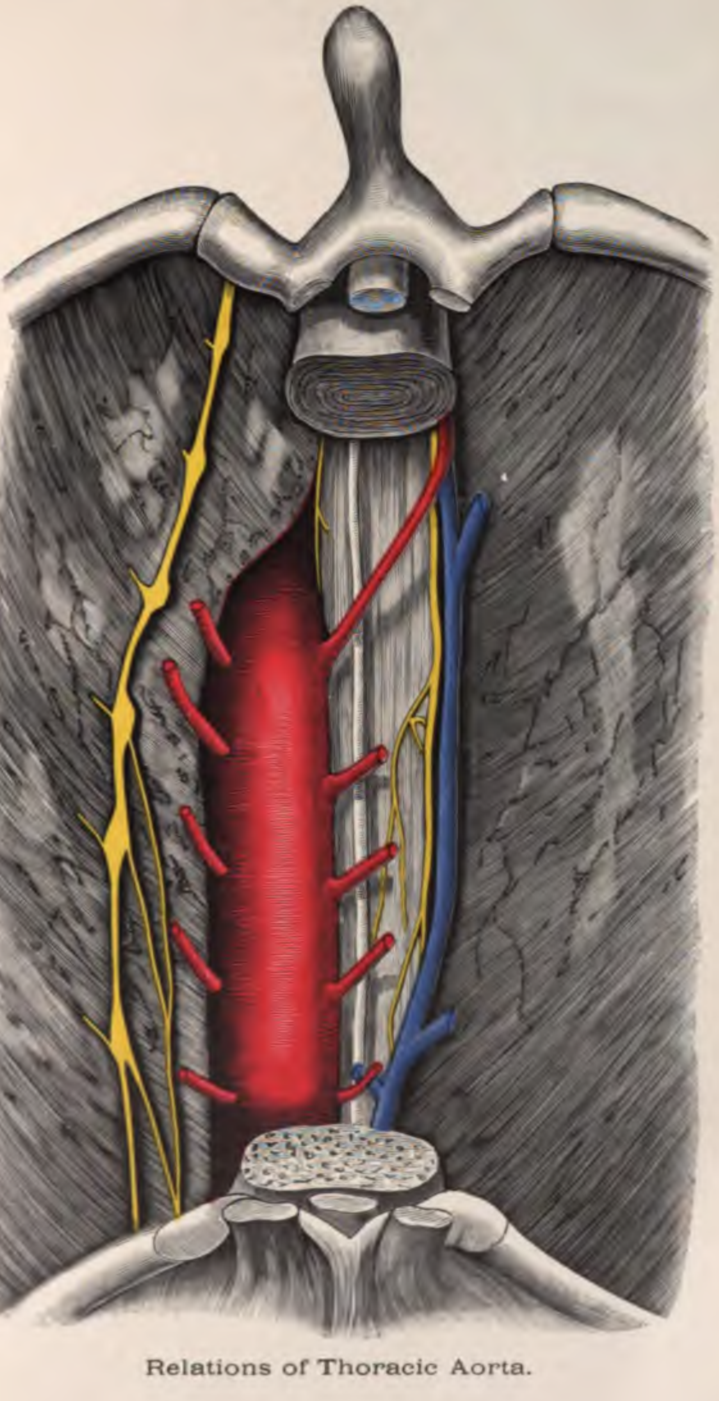
FIG. 197.



Position of the great vessels at the base of the heart; 1, thyroid vein; 2, azygos vein; 3, right pulmonary artery; 4, internal jugular vein; 5, subclavian artery; 6, subclavian vein; 7, first rib; 8, right lung; 9, right pulmonary veins; 10, superior vena cava; 11, left auricle; 12, left innominate vein; 13, trachea; 14, arch of aorta; 15, ligamentum arteriosum; 16, left pulmonary artery; 17, subclavian vein; 18. left lung; 19, left pulmonary veins; 20, pulmonary artery; 21, ascending aorta. (Spalteholz.)

Aspiration of the heart itself—cardiocentesis—will only be briefly mentioned. Sloan recommends this step in connection with the successful treatment of a girl, nineteen years of age, suffering from articular rheumatism with pericardial effusion. The girl collapsed and was supposed to be dead. The trocar which had been introduced suddenly had entered the right ventricle. Eight to ten ounces of

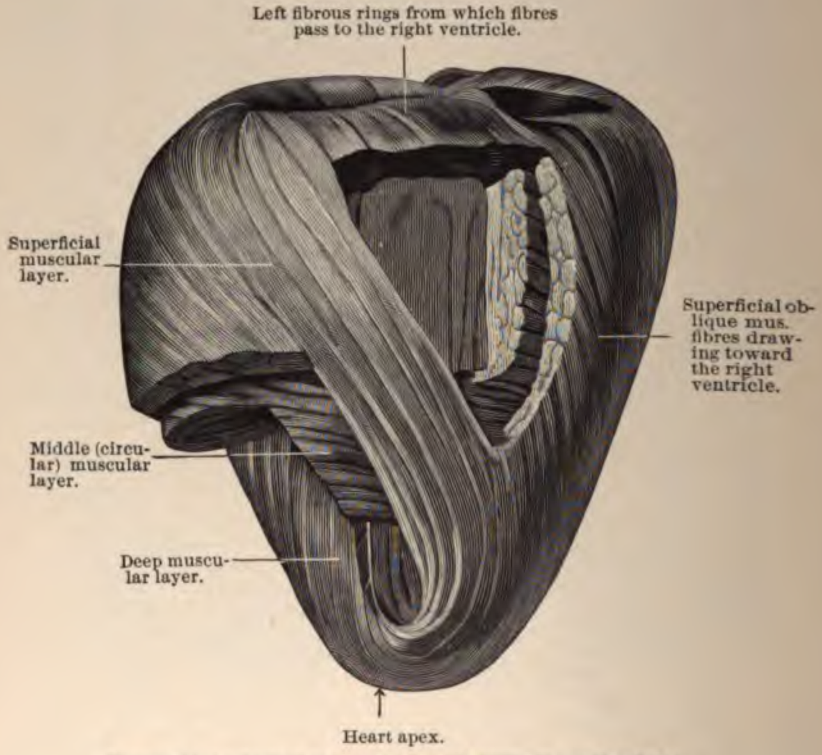
PLATE XVI.



Relations of Thoracic Aorta.

varies in the hands of different surgeons. Délorme and Mignon resect the cartilage of the fifth and sixth ribs after dividing the soft parts 1 cm. to the left of the sternum from the fourth to the seventh rib. Two lateral incisions (Fig. 199) are made at either end of the longitudinal one and the flap is reflected. After resecting the cartilage the internal mammary artery will be exposed. (Fig. 200.) This must be drawn to one side with the flap above mentioned. The method recommended by Ollier and made use of by Durard seems to the author to be simpler and more practical. An incision is made over the middle of the fifth costal cartilage (Fig. 201), beginning at the middle of the sternum. The cartilage is exposed and resected, and the internal mammary artery is tied. The triangularis sterni and the pleura are drawn to one side and a finger introduced to ascertain whether sufficient space is furnished. When this is not the case a portion of the sternum may be resected. The pericardium may now be opened and a large rubber drain introduced. The author does not wash out the pericardium, or only once immediately after the operation, for the purpose of removing large pieces of fibrin. The wound is closed by the

FIG. 202.

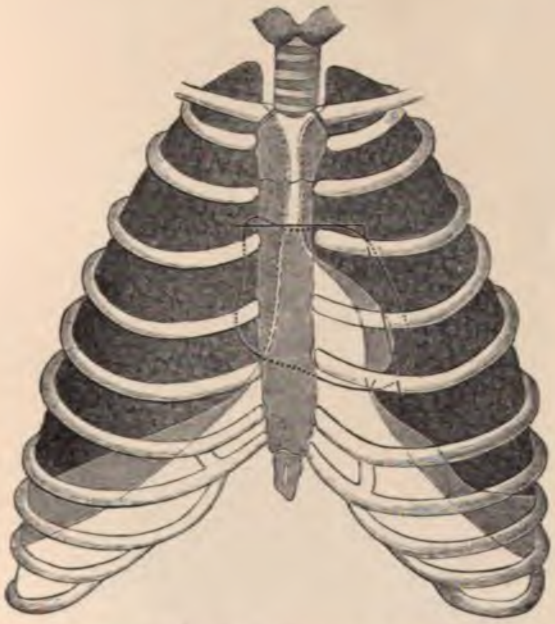

Left fibrous rings from which fibres pass to the right ventricle.
Superficial muscular layer.
Superficial oblique mus. fibres drawing toward the right ventricle.
Middle (circular) muscular layer.
Deep muscular layer.
Heart apex.

Course of the principal muscles of the left ventricle. (Spalteholz.)

familiar protective dressing. The results following incision and resection of the costal cartilages are favorable. Kobert collected 35 cases of purulent pericarditis in which this operation had been done, and showed 43 per cent. of recoveries.

Other Operations on the Heart.—Certain surgeons (Langenbuch) have recommended exposure of the pericardium and direct massage of the heart in collapse due to chloroform. As far as the author knows, no favorable results have followed this procedure. In a case of chloroform collapse he exposed the heart after all sorts of resuscitative measures had been tried and performed rhythmical compression with the hand. Each application of pressure was followed by entrance of blood into the vessels. The face, which was pale, became momentarily red, but when the pressure was removed resumed its death-like hue. The heart itself contracted several times so that the pulse could be felt, although the final result was negative.

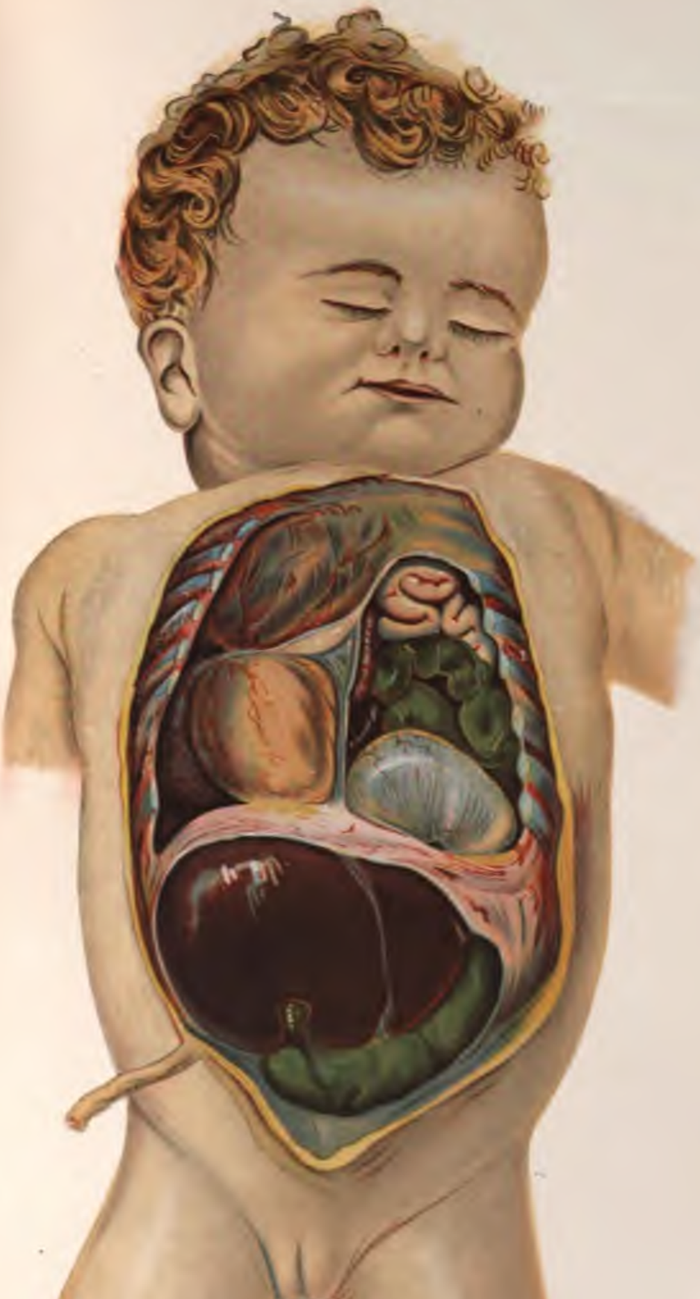
FIG. 203.



Flap of skin, muscles, and bone for exposing the pericardium. (Rydygier.)

When this method is to be made use of, or when the pericardium is to be exposed in cases of injury or for the removal of tumors, the author considers it important that the exposure should be more extensive than heretofore recommended. Rydygier's suggestion to form a triangular flap, consisting of skin, muscles, and bone, seems to the author best adapted to give sufficient room. A horizontal incision is made immediately above the third rib and carried across the sternum, reaching beyond this structure on both sides and a little more on the left side. (Fig. 203.) The second incision extends downward from the left end of the first to below the fifth rib, corresponding about to the seat of junction with the costal cartilage. The periosteum is carefully lifted up from the sternum in the line of incision and the bone divided with bone-scissors, a chisel, or a saw. The cartilages of the third, fourth, and fifth ribs are divided close to the bony rib in the same way. One should keep close to the under surface of the bony flap between the muscle and the sternum and separate the entire flap without injuring the pleura or pericardium. If there is any difficulty in turning the flap back, one can easily resect the sixth rib with a knife if necessary. The exposure of the pericardium is extensive. The blood is not beaten to a foam, as described by Riedel, and the conditions may be rapidly investigated, which is of great importance.

PLATE XVII.



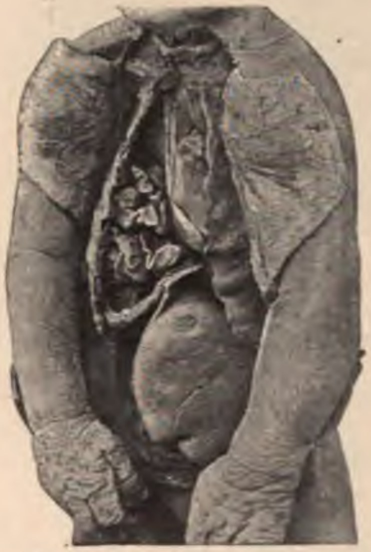
Congenital Defect of the Diaphragm.

CHAPTER XVIII.

SURGICAL DISEASES OF THE DIAPHRAGM.

THESE conditions are extremely rare and are usually congenital anomalies. According to Hertwig, the chest cavity and pericardial cavity begin to separate from the abdominal cavity by a transverse fold developing from the anterior and lateral wall of the trunk and presenting a free edge in the centre and behind. This is called the septum transversum. After the pericardial cavity has been separated from the pleural cavities by the pleuropericardial folds other folds develop from the posterior walls of the trunk that unite with the septum transversum and form the posterior portion of the diaphragm. The diaphragm therefore consists of an older ventral portion and a more recent dorsal portion. The final condition of the diaphragm is produced by the muscles of the trunk extending inward between the connective-tissue folds. When the dorsal and ventral parts do not become united on one side, a diaphragmatic opening remains which represents a communication between the chest and the abdominal cavity. When this is small, it is recognized only by symptoms referable to the digestive

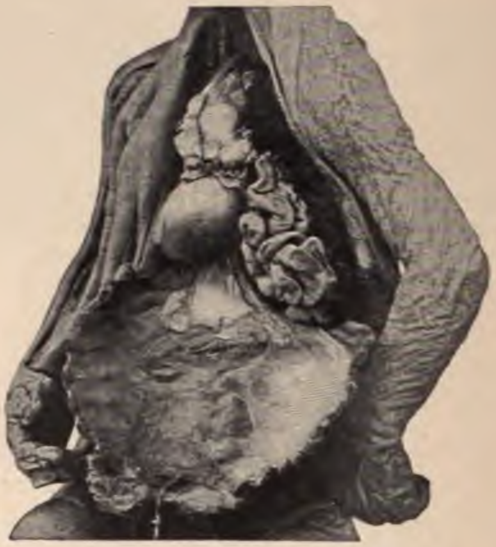
FIG. 204.



Congenital hernia of the diaphragm.

organs, and will be considered in that connection. When the deformity is extensive, there is usually coincident deformity of the abdominal wall and liver, so that the individuals are hardly ever viable. Figs. 204 and 205 illustrate these cases. Both diaphragms show an error of development in their centre which has allowed a large portion of the abdominal viscera to enter the chest. In some cases the diaphragm is completely absent. The prognosis is grave. The majority of the children do not live; and even if they are alive at birth, they usually cannot be kept alive, or the difficulties in doing so are in proportion to the quantity of abdominal contents that has entered the thorax.

FIG. 205.



Congenital hernia of the diaphragm.

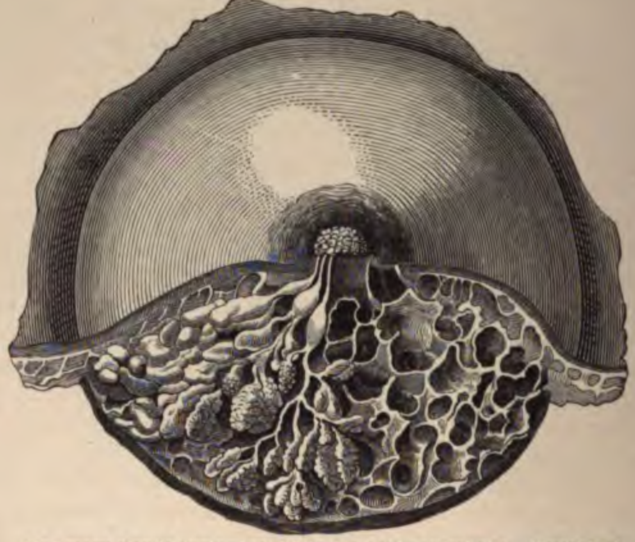
Perforation of the diaphragm due to inflammatory processes of the digestive system or gastric ulcer or duodenal ulcer, or after rupture of subphrenic abscesses, will be considered elsewhere.

MALFORMATIONS, INJURIES, AND DISEASES OF THE MAMMARY GLAND.

Anatomical and Physiological Remarks.—The female breast extends normally from the third to the sixth or seventh rib, and from the margin of the sternum to the anterior axillary line. It covers the larger part of the pectoralis major and is easily movable on the fascia of this muscle. The skin is easily movable over the gland itself. When the gland is tense, especially during lactation, the skin cannot be lifted off. About fifteen to twenty milk-ducts with very fine openings terminate in the nipple, which is covered with very delicate skin, as is also the areola. The irregular areola contains sebaceous and sweat-glands, which may be the source of cysts or inflammation. There are numerous smooth muscle-fibres in the nipple and areola that contract when irritated mechanically and render the nipple itself longer and firmer. According to Hennig, these muscle-fibres extend into the gland for a considerable distance. During pregnancy, accessory glands may develop (five to fifteen). These appear as small elevations in the areola and have independent openings. Beneath the mammary gland is a varying quantity of fat, which extends inward from the surface and forms in many cases the larger part of the breast. The gland itself is an acinous gland, and develops as the glands of the skin from the rete Malpighii, so that the connective tissue lying beneath the gland upon the pectoral muscles is still to be considered subcutaneous tissue. The gland consists of a number of small vesicles that do not communicate with one another, and are embedded in connective-tissue stroma. Macroscopically the gland appears as a firm connective-tissue mass, and is not sharply outlined toward the surroundings, and seems to have connective-tissue prolongations in all directions.

Up to puberty the glands develop alike in both sexes. After this period development ceases in the male and retrogressive changes take place after the thirtieth year of life. In the female the gland develops more and more with womanhood, and during the period of lactation reaches the height of its physiological increase. The number of acini is greatly increased, the lobes become larger, the connective tissue is more vascular and becomes scarce in proportion to the increase of gland-tissue. The same applies to the fat. The milk-ducts become distended just as do the acini, especially just before opening into the nipple. During the period of lactation the mammary gland may be extremely large, and may extend even into the axilla. After lactation the glands gradually diminish in size, the acini become smaller, although the milk-ducts remain distended. The sinus does not disappear and the gland retains a distinct lobular outline. The interacinous connective tissue increases again, which blurs the outline of the gland itself, so that it is difficult to tell from the surrounding connective tissue. The gland-tissue becomes atrophied at the monopause. The acini collapse, the glandular epithelium disappears, and only the ducts remain, which frequently undergo cystic enlargement. The breast of an old woman consists of connective tissue and fat and old glandular sinuses. The shape of the gland may be restored by development of the panniculus adiposus.

FIG. 206.

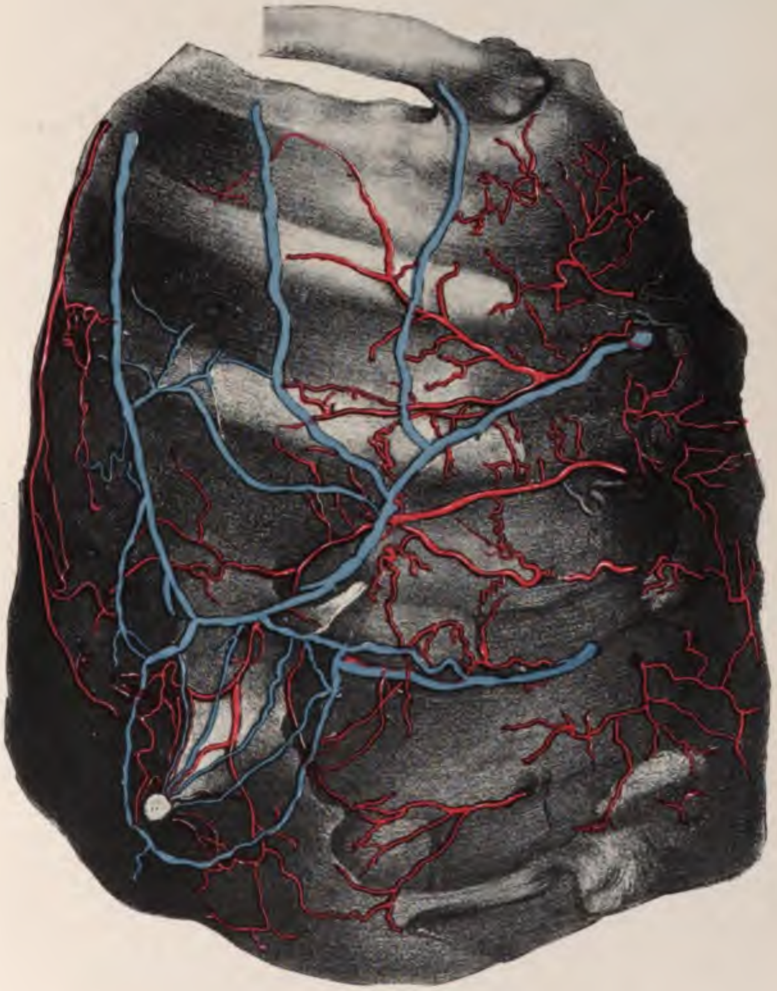


Mammary glands during lactation, one-half natural size. (Luschka.)

Generally speaking, there are three corners of a breast: an inner, an inferior external, and an upper external. The latter extends upward and outward toward the axilla along the pectoralis major muscle, and may be intimately connected with the axillary lymphatic glands, whereas the connective-tissue band between the mammary gland itself may be very slight. This corner appears cut off, as it were, and resembles an accessory gland. This axillary lobe is of especial importance to the surgeon not only in operations on cancer of the breast, but also in inflammatory processes of this lobe itself.

The mammary gland is intimately connected to the skin by means of bands of connective tissue, the ligaments of Cooper. Arms of gland parenchyma may extend along these connective-tissue supports almost to the papillary layer. Heidenhain has found connective-tissue projections from the gland extending into the intermuscular septa of the pectoralis major and containing epithelium, so that the mamma is

PLATE XVIII.

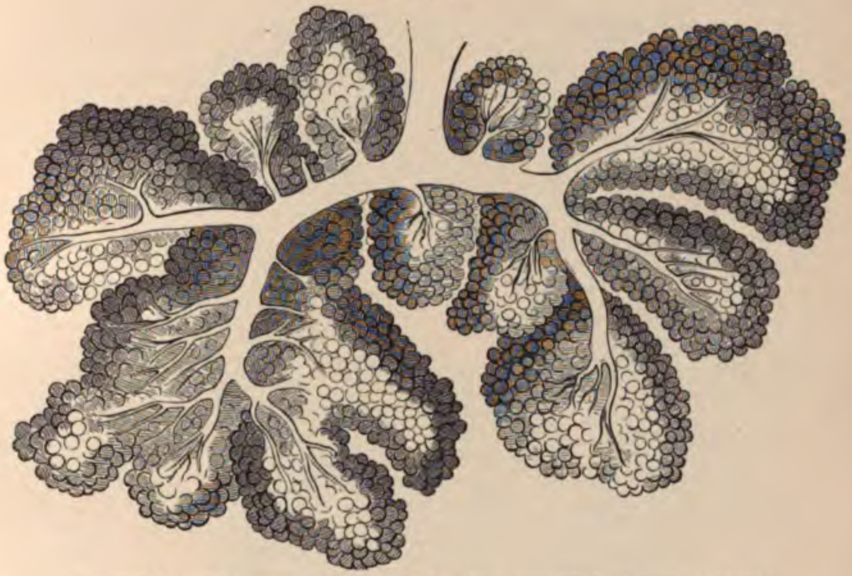


Showing Arterial and Venous Supply to Breast.
(Cooper.)

anchored in all directions. Oelsner calls attention to the fact that the mammary gland is sharply outlined below. The skin forms a fold here which is connected with the underlying tissue by short firm bands of connective tissue with very little interposed fat. For this reason carcinoma at the lower margin of the gland involves the underlying tissue very soon.

The arterial supply of the mammary gland is derived from the internal mammary artery, from the perforating branches of the second, third, and fourth intercostal arteries at the upper and inner part. The lower and external portion is supplied chiefly by the long thoracic. A large branch is given off from this artery which runs along the lower margin of the pectoralis muscle to the skin and nipple. There are abundant anastomoses between the main arteries. The upper and lateral portion of the gland is supplied in part by the superior thoracic and acromiothoracic arteries. The veins correspond to the arteries and terminate in the internal mammary and long thoracic vein. The subcutaneous veins are large, and several cross over the clavicle and end in the external jugular vein. Others terminate in the axillary vein. These subcutaneous veins form a network, and beneath the areola there is frequently a circle (circulus venosus Halleri) which takes away the blood from the nipple.

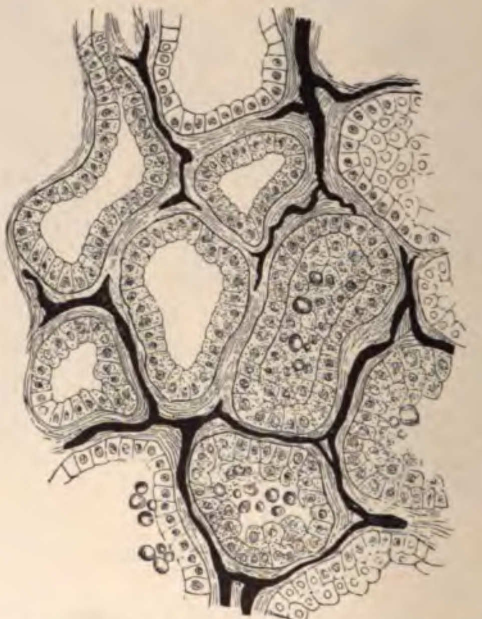
FIG. 207.



Injected lobe of mammary gland during lactation, magnified 70 times. (Langer.)

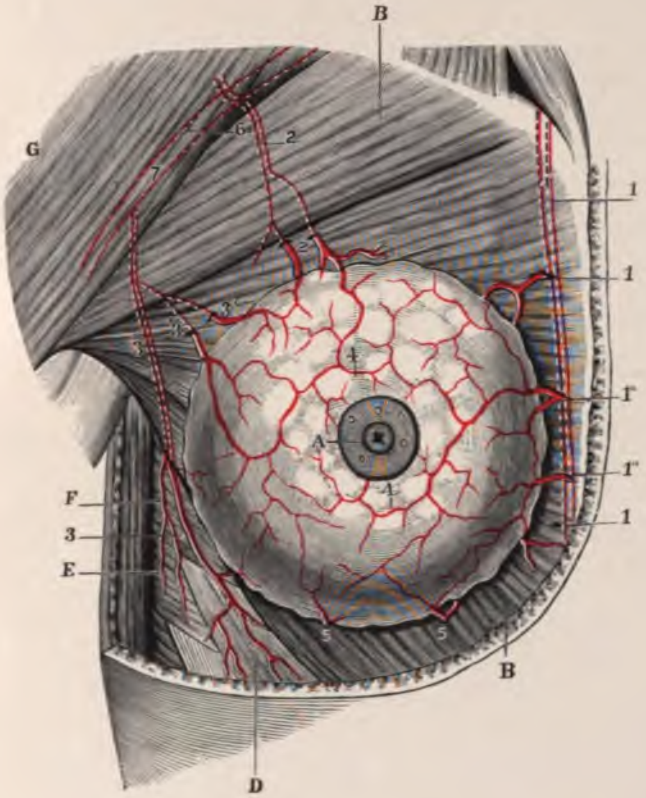
The lymphatics of the breast are of great importance. Some of these belong to the skin, and are especially numerous in the nipple and in the areola. This cutaneous network communicates with a series of lymphatics beneath the areola by a number of small twigs. This latter network communicates with the lymphatics of the gland itself, which surround the lobes and converge toward the nipple and surround the milk-ducts. All of the lymphatics of the breast and overlying skin join at the inferior external margin of the breast in two or three large trunks which pass upward and empty into the axillary glands. The first gland is situated along the inner margin of the axilla beneath the pectoralis major on the third rib, and is the gland to undergo cancerous degeneration first in carcinoma of the breast. According to Henle, there are ten or twelve lymph-glands in the axilla. The superficial ones are immediately beneath the fascia, while the deeper ones extend along the vein upward above the clavicle. The chief mass of axillary glands is grouped around the place where the long thoracic vein and the subscapular vein enter the large vessel. There is a mass of fat in front and behind the vein filled with lymphatic vessels. (Kõnig.) Some of the lower cervical glands receive lymphatics from the axilla, which explains the early involvement of these glands in carcinoma of the breast. According to Luschka, there are deep-seated glands along the pectoral surface of the mamma which accompany the internal mammary vessels. These are supposed to furnish the communication between the lamphatic vessels of the intercostal spaces and those farther on in the chest cavity. This

FIG. 208.



Transverse section through the tip of a milk-gland, with injected vessels. (Langer.)

PLATE XIX.


B
G
6
2
7
1
2'
1
3'
3
4
1''
A
1''
4
F
1
3
E
5
5
B
D

Showing Arterial Supply of Breast. (Testut.)

is denied by the corresponding results of investigations of Sappey and Sorgius, who claim that these nodes become involved only when a cancer has progressed beyond the limits of the gland itself. (Merkel.) Recent investigations by Heidenhain, Gerota, Grossmann, Stiles, Rotter, and others, have proved that in carcinoma of the breast the lymph-channels in the retromammary fat may become infected with carcinoma cells from the breast gland. The nerves supplying the skin over the gland are derived in part from the supraclavicular nerve, in part from the lateral and perforating branches of the second to the sixth intercostal nerves. The nerves supplying the gland itself are derived from the perforating branches of the fourth and sixth intercostal nerves, the smallest branches of which may be traced to the milk-ducts and even into the nipple itself.

CHAPTER XIX.

CONGENITAL MALFORMATIONS OF THE MAMMARY GLAND.

CONGENITAL absence of the mammary gland (amastia) is as rare as absence of any other gland. When this error of development is found, there is usually lack of development of the genitals. It is more frequent to have the female breast remain infantile (micromastia.) Two nipples have been observed on one breast. This may be due to subdivision of the original nipple or to overgrowth of one of the accessory milk-ducts. Supernumerary nipples and mammary glands (polymastia) are usually arranged in two lines that converge from the shoulder over the normal gland as far as the genitals. (Merkel.) This corresponds to the arrangement in the embryos of mammalia as described by O. Schulz. Besides glands occupying this typical position, there may be glands on the shoulder, the back, over the deltoid, on the outer surface of the thigh, and beneath the trochanter. These accessory milk-glands vary histologically. There may be no ducts whatever. During pregnancy accessory mammæ usually become swollen and painful. The number of supernumerary glands may vary considerably (eight, Neugebauer). Uusually there is only one, which is found 8 cm. below the normal gland.

CHAPTER XX.

INJURIES OF THE MAMMARY GLAND.

INJURIES of the mammary gland by sharp instruments differ in no way, as far as treatment and recovery are concerned, from injuries to similar tissues, and when the wound is treated aseptically it is fair to suppose that it will heal by first intention. The mammary tissue tends to heal readily, as the author has had repeated occasion to observe after excision of benign tumors. Stab-wounds of the breast present no special peculiarity. Damage due to some blunt instrument is quite common and causes subcutaneous or intraglandular extravasation of blood. This is slowly absorbed or encapsulated and may become infected and be followed by suppuration. There is no doubt that trauma of this sort may lead to changes in the breast that later predispose to the development of cancer. Burns in this region may displace the nipple considerably on account of the contracting scar-tissue, but need not necessarily give rise to disturbances during lactation.

CHAPTER XXI.

DISEASES OF THE MAMMARY GLAND.

DISEASES OF THE NIPPLE AND AREOLA.

THE skin of the nipple and areola is thin and delicate, and is easily excoriated by mechanical irritation, such as the sucking of a child. These fissures are extremely painful, so that at times it is impossible to have the child nurse. They may also be the seat of entrance of bacteria. For this reason special care should be given to the nipple during pregnancy and lactation. The region should be painted with alcohol and glycerin alternately, and fissures must receive especial attention early. The region should be carefully washed with astringent solutions, such as lead acetate, boric acid, or 0.5 per cent. solution of aluminum acetate, and the nipple should be covered with antiseptic salves or guaiacol, and fissures touched with silver nitrate. Nipple-protectors have been recommended. Thrush has been repeatedly transferred from the mouth of the child to the fissure, which then has an aphthous character. (Hausmann.) Cleanliness will guard against accidents of this sort.

Eczema, with abundant crusts, is not infrequently observed around the nipple, and is usually due to lack of cleanliness. This condition is at times persistent and may extend over the entire gland. Treatment must first of all be directed to softening and removing the scabs by smearing the region with oil or salve. After this the places should be painted with a 10 per cent. solution of salicylic acid in alcohol, or treated dry with some powder. Long-continued eczema may favor the development of carcinoma on account of the chronic inflammation and irritation. (See Paget's disease.)

Syphilitic lesions are sometimes noted around the nipple, usually mucous patches, rarely primary sores. The usual antisyphilitic treatment should be administered and the child removed from the breast, of course. Axford has endeavored to improve retracted and small nipples by operation so as to enable the child to nurse. He made a series of circular incisions and wedged-shaped incisions beneath the nipple and used a pucker suture to lift up the nipple. Primary ulcers of the nipple and areola are uncommon. Sebaceous cysts sometimes develop in the glands of the areola, and epithelial carcinoma has been reported in this region. The author had personally an opportunity to operate on an epithelial carcinoma developing in this region, probably from a sebaceous gland. The nipple was excoriated and covered with irregular dark granulations and felt distinctly indurated. The areola was normal and the margin distinctly outlined toward the nipple and covered by normal epithelium. The nipple was excised with a piece of gland about the size of a hen's egg. No recurrence has been reported in three years.

James Paget called attention to the fact, in 1874, that carcinoma of the mammary gland might be secondary to disease of the nipple or of the areola. The nipple becomes intensely red and has a fine granular appearance, as if the epidermis had been lost. It resembles acute eczema or acute balanitis. A clear yellowish fluid is secreted and there is burning pain. Sometimes there is chronic eczema with formation of vesicles without disturbance of the general condition. In one case reported this resembled psoriasis and lupus, and did not show tendency to extend to the mammary gland as in the first two varieties. Treatment was unsuccessful and inside of two years carcinoma of the mammary gland developed, not in the diseased portion of the skin, but in the gland itself. Between these foci was healthy tissue. Paget has reported 15 cases in women from forty to sixty years of age. Several cases have been reported in German clinics. Paget's disease proves the correctness of Busch's opinion that epithelial carcinoma of the skin first appears as an overgrowth of epithelium on the surface. Chronic eczema of the nipple and of the areola, and superficial ulcerative processes, should always receive careful attention.

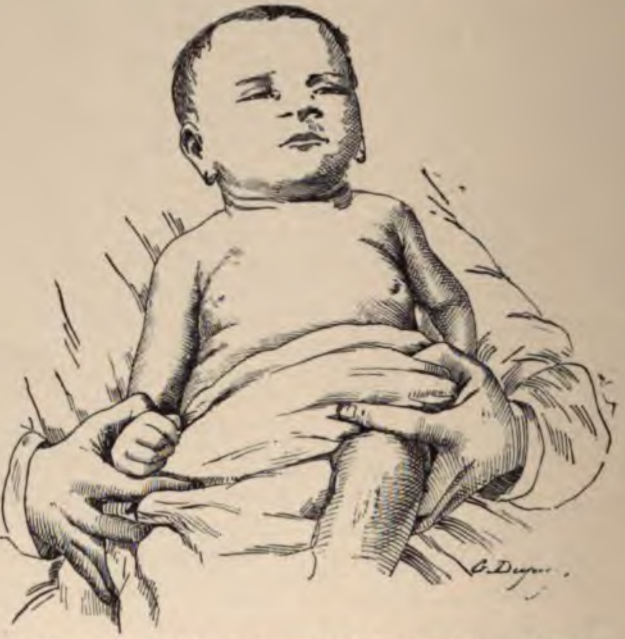
G. B. Schmidt has reported a case of fibroma pendulum papillomitosum. The entire right nipple had been altered to a pedunculated, hard, irregular tumor, covered by thin reddish translucent skin. The breast itself was normal. Sendler reports a case of angioma cavernosum pendulum of the nipple, and v. Eiselsberg has observed a case of true hypertrophy.

INFLAMMATION OF THE MAMMARY GLAND.

Mastitis.—Inflammations of the breast may occur at any time of life in either sex, although the newborn, males at the time of puberty, and women are chiefly affected. Women at the time of the climacteric sometimes show inflammatory enlargement of the mammary glands. These inflammations manifest themselves in different ways, and it is of practical importance to separate the varieties. There is sometimes a distinct swelling of the breast with reddening of the skin in newborn infants. In some cases a clear or milk-like secretion may be squeezed out. The cause is unknown, and it is not certain that the process is inflammatory in all cases. A. Kölliker considers that this affection is due to physiological development of the mammary gland, and is so slight in the majority of the cases that it is not noticed. As a rule the breast begins to swell after the cord has fallen off—that is, from the fourth to the sixth day. The conditions may last several days and become of considerable size, and may even suppurate. De Sinety believes that the secretion is due to two different processes: degeneration of the epithelium which fills the ducts with debris before birth, and actual production of milk.

In mastitis neonatorum the swelling may be reduced by lead acetate compresses or aluminum acetate or a salve. If suppuration takes place, the abscess should be opened immediately. As a rule the process becomes localized and heals without further disturbance.

FIG. 209.



Caking of the milk in both breasts of a newborn infant. (Koplik.)

Inflammatory painful swelling of the breast is sometimes observed at puberty in girls as well as in boys. The gland becomes tense, hard, and elastic, so as to resemble a firm disk, or circumscribed small nodules can be felt in the gland. The breast is sensitive to pressure, so much so that movements of the arm may cause pain. In slight cases there is a dull ache in a moderately swollen gland, the nipple is prominent, and the areola may be intensely pigmented and at times reddened. After two or three weeks all the symptoms disappear, only a slight increase of pigmentation remains. In other cases the pain increases and the nipple becomes red and inflamed. The breast becomes double its normal size and several hard strands leading to the nipple can be felt. The lymph-glands in the axilla may be swollen. This condition may last several weeks, and finally disappear, although in rare cases suppuration takes place. Moist antiseptic poultices and moderate pressure should be used. When suppuration takes place, early incisions should be made.

In mastitis adolescentium the painful swelling of the breast of young girls appears at the time of menstruation. The cause is probably the development sexually. Hemorrhages from the breast have been observed as vicarious menstruation, especially during the period of development. These disturbances of menstruation should be properly dealt with and pressure-bandages should be used.

At times the mammary gland may become infected through wounds or boils, and even blunt injuries if repeated may be followed by mastitis. Traumatic mastitis is observed especially in workmen who are obliged to press tools against the chest. Subcutaneous hemorrhages are observed in these cases at times. Suppuration or chronic inflammation may eventually supervene. H. Cameron reports small chronic abscesses surrounded by fibrous tissue in the breast of diabetic women. In all of these cases a diagnosis of scirrhus was made, and the condition became evident for the first time at the operation.

Inflammatory processes have been observed to develop in the breast of women immediately before or after the menopause. The process is extremely chronic and produces firm circumscribed infiltration of the gland. The condition may resemble carcinoma closely, especially when the axillary glands are infiltrated. Fibrous nodular infiltrated areas, cicatricial contraction and retraction of the nipple may be present in one or both breasts. The changing size and consistence of the tumor, which may be larger or smaller, harder or firmer, is of valuable differential importance. The absence of pain, especially lancinating pain, is also of value. Expectant treatment—pressure, inunctions of mercury or iodine, which act as a sort of massage—has been followed by disappearance of the tumor within a few weeks. (Verneuil.) These cases of mastitis of the menopause described by French surgeons must be extremely rare, and should be carefully considered, so as not to be confounded with carcinoma. It is recognized that there are chronic cases of inflammation in which the process affects the interstitial tissue chiefly. This condition is known by the name fibroma mammæ diffusum, induratio benigna, etc., and belongs in all probability to the class of cases above described. Accurate histological examinations are not at hand. Chronic cystic mastitis may be confounded in its early stages with the former condition.

The author has personally never seen a case of chronic interstitial atrophic mastitis, although he has repeatedly operated upon atrophic carcinomata that were supposed to be chronic mastitis.

Mastitis Puerperalis.—Purulent inflammation of the mammary glands is most common in women, and especially during lactation. According to the statistics of Bryant, Nunn, and Billroth, 171 of 218 cases occurred during this period ; 13 were in pregnant women and 34 in non-pregnant women. Primipara and nursing women are more predisposed to inflammation than multipara.

ETIOLOGY.—The cause may vary. Infection usually takes place through the lymphatics and the scratches or fissures around the nipple serve as a point of entrance. It must be recognized that the pus-producing organisms may in other cases enter the ducts directly. Cases of mastitis in which the nipple is absolutely healthy favor this view. The retention of milk is secondary to infection, and not the cause of infection. Lack of cleanliness and carelessness on the part of the mother may produce infection in other ways, as in Sarfert's case, in which a mother transferred gonococci from the vagina to the nipple by means of her hand. An abscess of the breast developed, the pus of which contained numerous diplococci and the child died of catarrhal enteritis. Infants with gonorrhœal ophthalmia may infect the nipple and mastitis may result. It has been proved with equal certainty that the mammary gland may become the seat of metastatic inflammation in puerperal metritis, which develops as a rule within four weeks postpartum, especially during the third or fourth week. At first the inflammation does not involve the entire gland, only a single lobule, and usually the lower and outer, although the entire gland may become involved provided the abscess is not opened at a sufficiently early date.

There are various sorts of mastitis: simple parenchymatous and suppurative infected mastitis. (Bumm.) The former is produced by stagnation of the milk in the mammary gland when there is some mechanical obstruction. Hyperæmia, infiltration, and dilatation of the glandular vesicles develop which resolve as a rule without suppuration. The infected variety of mastitis is followed by suppuration of the portion of the gland affected. This method of subdividing the varieties is of great importance. To determine in a given case which variety is present, it is necessary to examine bacteriologically the secretion from the gland very carefully.

SIMPLE MASTITIS, DUE TO STAGNATION, is uncommon, and usually appears early in the puerperium and is limited to one lobe of the gland. This form of mastitis is sometimes noted toward the end of pregnancy with premature appearance of the milk and sometimes late in the puerperium. Mastitis of stagnation is characterized clinically by very slight fever. The breast becomes swollen and painful, and individual lobes may be felt distinctly as firm nodules very sensitive to pressure. The skin is slightly reddened, and the lymph-vessels can be traced to the axilla. The secretion squeezed out of the swollen breast is milk without pathological bacteria.

Treatment.—The treatment consists first in removing the obstruction to the flow of milk. Suspension of the breast with slight pressure has proved of especial advantage in this direction. The milk should be removed from the breast rapidly and thoroughly, either by the infant itself or by some artificial apparatus. If it is desirable to suppress the secretion of milk, some cathartic and potassium iodide internally will produce the desired effect. Sometimes hard nodules remain in the breast long after the period of lactation has passed. This chronic induration of lobes of the mammary gland should be treated by iodine ointment, massage, and pressure-bandages.

INFECTIVE MASTITIS.—The second variety of puerperal mastitis is that due to infection. An abscess developing beneath the areola is usually small and ruptures quickly because of the thin overlying skin. In other cases the milk-glands and sebaceous glands of the areola are the seat of suppuration. Either of these processes may extend to the parenchyma of the mammary gland itself, or cause inflammation of the subcutaneous tissue of the breast. This condition is not uncommon and frequently follows abrasions of the nipple. Clinically, it resembles erysipelas with suppuration. The germs of infection may penetrate along the interstitial connective tissue and cause suppuration in this region, or they may enter the milk-ducts and attack the interior of the gland. Stagnation of milk favors invasion by bacteria, which is the reason why simple mastitis due to accumulation of milk is frequently followed by abscess if especial care of the nipple is not taken. The methods of infection and the subsequent changes produced vary. It is not always possible to determine clinically the method of infection, because the inflammation may extend from one tissue to another, so that finally the abscess may involve the gland-substance itself as well as the tissue in front of and behind it (paramastitis).

In mastitis due to infection there is always a high temperature and there may be chills. The breast is painful and when nursing the child the pain may become unbearable. One or two lobes of the gland may be enlarged, firm, and painful to pressure. The inflammation gradually extends to the peripheral portion of the breast, the skin becomes reddened, there is œdema, and a soft spot can sometimes be felt in the middle of the indurated area. Later the pus finds vent at this spot.

Treatment.—Mastitis due to infection sooner or later causes suppuration, so that early incision into the infiltrated gland-tissue is indicated just as in any other suppurating process. Suppuration occurs successively in one lobe after another, and small incisions into portions of the abscess near the skin do not give the desired result. Anyone who limits himself to incisions of this sort may wait for weeks before the case recovers, because other lobes of the breast are continually reinfected and suppurate. The author cannot urge too emphatically the necessity of large radiating incisions. An incision is indicated even before fluctuation is present, when the history, the temperature, the œdema of the skin, and increasing pain indicate that suppuration will take place sooner or later. When pressure and antiseptic poultices do not produce improvement within a few days, suppuration is almost certain to take place. It is evident, of course, that with these early incisions one should not expect to find a large abscess cavity, but distinct pus foci will always be found. By emptying these a limit is set to extension of the suppurating process.

Large abscesses should also be opened with free incisions. Small incisions never give sufficient drainage. One is obliged to open the abscess again and again. Ten to twenty incisions may be necessary, and convalescence is protracted, and finally all that remains is an atrophied gland with considerable scar-tissue, which later may favor the development of carcinoma. The author always etherizes the patient and makes incisions 10 to 15 cm. long, introduces a finger into the abscess cavity, breaks up partitions between adjoining cavities, and makes counteropenings if necessary. The edges of the wound are now held apart with retractors, and the infiltrated purulent, sloughing gland-tissue is removed with a curette, forceps, and scissors as thoroughly as possible. It is astonishing how much sloughing tissue can be removed with a curette. Any tabs presenting in the wound should be removed with scissors. The abscess cavity should be washed out with weak antiseptic solutions, such as 5 per cent. zinc chloride, and then packed with iodoform gauze around a drain. The incision is then closed in its upper part with sutures down to the drain. An antiseptic bandage with moderate pressure is then applied. Radical interference of this sort will be followed by rapid recovery. The healthy portions of the gland remain intact and complete fibrous contraction of the gland is avoided. The wound heals kindly without a very disfiguring scar. Fatty embolism following this incision, as reported by Fergusson, is an extremely uncommon accident. The incisions should always radiate from the nipple. Any other sort of incision would injure the ducts of the glands.

When the pus has infiltrated the loose connective tissue between the gland and the pectoral fascia, the breast is lifted off from the muscles by the retromammary suppuration. The pus extends rapidly beneath the surface and extensive incisions around the lower margin of the breast are indicated. One should not delay cleaning out the abscess cavity and thereby endeavor to avoid protracted suppuration and sinuses. When the suppuration becomes scant, the drains should be successively removed. If allowed to remain too long, they favor persistence of sinuses, which must be opened up, curetted, and cauterized to favor healing. In severe cases it may be necessary to amputate the breast.

The author considers this method of treating suppurative mastitis the best because it offers the most favorable chances for rapid recovery and for preservation of the portion of the mammary gland not involved in the process. Many women will not submit to such extensive surgical procedure, and in the meantime the application of ice-bags is the next best method of treatment. Many nursing women will not use cold for fear of "catching cold," and in these cases one should use antiseptic solutions.

When mastitis disappears under this sort of treatment it was probably due to stagnation, and not to infection. Bacteriological investigation of material squeezed out of the breast will give reliable information on this point.

Eliot recommends the use of spirit of turpentine locally in puerperal mastitis, and claims to have had very good results. The inflamed areas are thoroughly washed with turpentine and a turpentine poultice is applied. Eliot observed no bad after-effects from this manner of treatment. Murphy corroborates Eliot's statement, and emphasizes that with this method of treatment the secretion of milk is diminished or ceases entirely.

Kaarsberg endeavors to remove the milk and the pus at the same time by massage. This must be repeated in the early days three times daily; later less frequently, and should be continued for one-half hour at a sitting. An anæsthetic may be necessary when the pain is severe. Thirteen of 15 cases were cured in this way, and 2 had to be incised.

Rubeska recommends thorough cleansing of the skin with corrosive sublimate, aspiration of the milk, and the application of ice-bags. When there are chills, high fever, and intense pain, he injects two or three syringefuls of a 3 per cent. solution of carbolic acid.

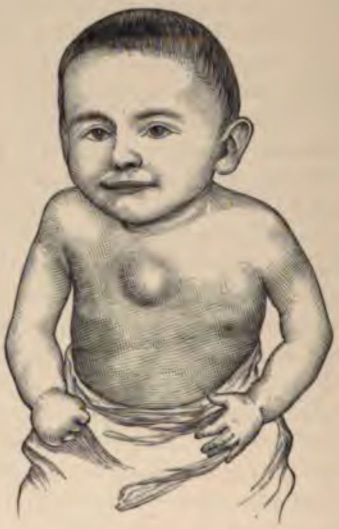
The inflamed breast cannot be suckled on account of the extreme pain. In mastitis due to stagnation it would seem to be the normal method of procedure to have the child empty the breast, but in mastitis due to infection the pathogenic bacteria contained in the milk would be harmful to the infant. Stagnation favors the development of pus-producing bacteria, so that the breast should be emptied artificially. When the mother is willing to give up nursing the child, this will be a great aid in improving the condition. The secretion of milk may be suppressed by saline cathartics and a few doses of potassium iodide. When puerperal abscesses of the breast are neglected, or when the asepsis is defective, there is great danger of general infection.

The after-effects of mastitis are contraction of the gland *in toto* or only in part, according to the extent of the inflammation and the region affected. There may be localized, indistinctly outlined, indurated areas in the breast which later may undergo carcinomatous degeneration. If the abscess cavity does not heal completely, sinuses remain which secrete small quantities of pus and a slight amount of milk. These sinuses may persist for months. They are lined with soft granulations which interfere with healing. They frequently lead to pus cavities situated behind the breast, and have a very tortuous course, which interferes with the exit of secretion. They should be freely opened and curetted. Scar-contractions may displace or occlude the ducts of the gland, just as the primary infection did. The secretion accumulates behind the seat of occlusion, the sinus distends, and a milk-cyst develops (galactocele). These retention-cysts are uncommon, and when present should be opened and drained. The retained milk undergoes change and may appear as an oily or butter-like mass. Concretions may form, following absorption of the fluid portion. These are white and resemble dried mortar.

Chronic Cystic Mastitis (König).—Synonyms: interstitial mastitis (Virchow); cystic disease of the breast (Reclus); cystadenoma of the breast (Schimmelbusch). The formation of multiple cysts of varying size in the mammary gland is not uncommon, and has been explained in various ways. Macroscopically there are found on the side of the breast toward the muscle round nodules of varying size, arranged singly or in bunches, and resembling dark vesicles. On incision the distended cystic duct is seen.

König observed that the interstitial connective tissue was swollen, showed an increased number of nuclei, and was infiltrated with leucocytes. The cysts and their ducts expand, the partitions disappear, and cavities develop that are filled with detritus and dark fluid. König believes that the duct system of the gland is first affected, because at no stage of the disease is the interstitial tissue alone involved. For this reason he has discarded the name interstitial mastitis.

FIG. 210.



Retention cyst of the chest.

Schimmelbusch believes that the first change is an overgrowth of the epithelium of the acini, and not dilatation or obstruction of the duct. There is no increase in the number of the nuclei and no inflammatory infiltration of the connective tissue. The acini gradually become distended and fill with epithelium. The centre breaks down, causing a cavity. According to this view, multiple cysts of the breast are the result of epithelial proliferation and cystic dilatation of the acini.

Roloff agrees with König, and considers the process to be inflammatory, but believes with Sasse that the microscopical picture of cystadenoma is by no means uniform. Sasse examined a large amount of material and came to the conclusion that both conditions could be present; that the latter developed in the acini and the former in the ducts.

Tietze claims that it is impossible to distinguish sharply between cysts with and cysts without papillary elevations—*i. e.*, adenomatous growth of the wall. He considers that the cystadenomata of Schimmelbusch are due to proliferation of the epithelium of the alveoli, forming epithelial papillæ with or without connective tissue, then glandular tabs, and finally carcinoma. He recommends the name cystomammæ, which includes multiple intracanalicular cystadenoma. W. Mintz considers that the condition is due to proliferation of the intralobular connective-tissue septa, which goes hand in hand with obliteration of the glandular cells.

The disease occurs at any time of life after puberty, especially in women who have given birth to children but did not nurse. Both breasts are frequently affected. Previous mastitis is a predisposing cause. There is almost always pain. In typical cases, especially in young girls during menstruation, one or both breasts become swollen and painful. This diminishes as the flow ceases and the diffuse swelling disappears. Small nodes remain, which feel leathery and fibrous, or there may be a flat, disk-like area of infiltration. According to König, the following symptoms are characteristic: On examining the breast between the thumb and forefinger the nodules can be distinctly felt. If the hand is placed flat against the breast, they cannot be felt. These nodules frequently are not to be palpated if the breast is compressed in any other way from before backward. The individual nodes are rarely more than an inch in diameter, are tense and may fluctuate. If pressure is brought to bear upon one of these masses, it may be at times possible to squeeze a milky or dark fluid out of the nipple. The skin does not become reddened and there is no tendency for the tumors to become adherent. In advanced cases the gland may feel nodular, just as if it were filled with beans or marbles. The nipples may be slightly retracted and the breasts are easily movable upon the muscles.

The large number of nodules, the smooth surface, fluctuation in the larger tumor, simultaneous disease of both breasts, increase in the size of the tumors and pain during menstruation, and absence of glandular enlargement in the axilla will determine the diagnosis, especially when the tumor is not adherent to the skin or underlying tissue. One should not forget that benign changes in the mammary gland may be the primary cause of papillary epithelial tumors in these cysts. If the character of the tumor changes in this way, the individual cysts grow quicker, the pain becomes more marked, and operative interference is indicated.

Chronic cystic mastitis in itself is a benign condition as long as the cyst remains small and causes no disturbance. The condition may remain unchanged for years. Medicinal treatment or pressure has no influence whatever. In doubtful cases it is justifiable to excise one of the nodules for diagnosis. Amputation of the breast is indicated when annoying symptoms, such as neuralgia, develop or when a radical cure is demanded. Partial excision does not prevent extension of the disease. In some cases of chronic mastitis cysts of sufficient size to be detected do not develop. Individual lobes of the gland show multiple nodular infiltration, and the women complain of drawing pain extending into the armpit. Sometimes a firm band can be made out beneath the lower margin of the pectoral muscle. This strand may contain several smooth nodules. Suspension of the breast, soft tight corsets, and poultices during the night will relieve the pain. In other cases, however, it may be necessary to keep the patient under continual observation.

Specific Inflammations of the Breast.

Tuberculosis of the Breast.—Tuberculous disease of the breast is uncommon and is found usually in women. No case of tuberculosis of the mammary gland before puberty has been reported. The women affected were usually scrofulous during youth and showed signs of tuberculosis elsewhere. The method of infection may vary. The bacillus may enter directly from without through the ducts, or it may reach the gland through the blood-current, or by extension of some tuberculous process in the neighboring organs, such as the axillary glands, ribs, or pleura. This latter method of infection seems to be most common, so that cases of primary tuberculosis of the mammary gland are extremely rare.

Symptoms.—Clinically tuberculosis of the breast manifests itself in various ways. A circumscribed cold abscess may develop in the breast. The gland gradually increases in size, becomes tense and fluctuating, and is outlined only in rare cases by a ring of dense infiltrated breast-tissue. The overlying skin is normal. On incision a thin cheesy pus is found and the abscess cavity is lined with a characteristic membrane. Sometimes the disease is disseminated. There are isolated tuberculous nodules that are at first separated from each other by normal gland-tissue, but which become confluent later. This variety seems to be the most common. The breast is very slightly enlarged, if at all, although circumscribed areas of induration with nodular surfaces can be made out on palpation. These nodules increase gradually in size, softening takes place in the centre and extends toward the skin, which becomes thin, bluish, translucent, and finally ruptures, allowing a thin crummy pus to escape from the sinus. The nipple is usually retracted and the breast is freely movable upon the underlying tissue. The axillary glands are swollen or may have undergone caseation.

The course is extremely chronic.

Diagnosis.—The diagnosis is easier the farther advanced the disease. In the early stages a preliminary diagnosis can usually be made, although it is difficult to differentiate from the neoplasm until softening takes place. When sinuses are present, the appearance of the sinus and the quality of the secretion will indicate tuberculosis. Microscopical examination of bits of tissue, bacteriological investigation, and inoculation of animals will estabish a diagnosis.

Prognosis.—The prognosis is favorable as long as the disease is limited to the mammary gland and axillary lymph-glands. If other organs are involved, the prognosis will depend on the amount of damage in this direction.

Treatment.—The treatment consists in amputating the breast and cleaning out the axilla. It has been shown that even the most radical local treatment, such as free open incisions, curetting the tuberculous foci, and the free use of iodoform, is not followed by permanent cure. This is easily understood because the neighboring lymphatics are always involved and tubercles are frequently found at a considerable distance from the original focus in lymph-glands which were supposed to be healthy. In cold abscesses it is justifiable to try free incisions, removal of the abscess membrane, and treatment with iodoform.

Actinomycosis of the Breast.—Very few cases of this condition have been reported. A case occurring in the author's clinic will be briefly reported : a woman, twenty-four years of age, with five children, the youngest four months old. The first she nursed, but not the last. The right breast was swollen for three weeks and was painful. There was induration in the lower inner quadrant. The skin was reddened and thick pus mixed with milk could be squeezed out of a small sinus. Three large radiating incisions were made and the necrotic tissue removed. After several weeks two of the incisions continued to discharge pus. The breast became infiltrated and could not be moved on the underlying tissue. A few actinomycotic granules were found in the pus, and a fluctuating swelling about the size of a hazelnut appeared over the ensiform cartilage. This focus was incised and curetted. After amputating the breast it was found that the perichondrium of the ribs was already invaded and that the granulations could be removed with a knife. Recovery. The patient did well with potassium iodide, but died later from internal recurrence. Microscopical examination showed that the larger part of the parenchyma of the breast had been destroyed and replaced by granulation-tissue which had undergone fibrous change. The pectoral muscle was also involved in this process. Pure cultures of actinomyces were obtained after Buchner's method.

Sometimes injections of 10 per cent. iodopin have been successful, but usually amputation of the breast will be necessary.

Syphilis of the Breast.—Gummatous mastitis is extremely rare and occurs in the late stage of syphilis as circumscribed lesions. Le Crain has recently reported a case of this sort which resembled a malignant growth very closely. Kennedy reported a case of gumma of the pectoral muscle close to the right breast, in a woman with a second lesion in the substance of the left mammary gland. This latter focus was as hard as a cancerous nodule, but easily movable on the underlying tissue and diminished considerably in size within a few weeks under potassium iodide. The treatment is the usual antisyphilitic one.

ECHINOCOCCUS OF THE MAMMARY GLAND.

This condition is extremely uncommon. The symptoms are those of a cyst which is said never to exceed the size of a hen's egg or that of a man's fist. The condition develops slowly without causing pain. The cyst contents are free from albumin and resemble water. Hooklets have been repeatedly sought for without result. Inflammation and suppuration may follow trauma and the tumor may resemble an ordinary abscess. Provided a correct diagnosis has been established, the cyst should be aspirated and iodine injected. Incision and removal of the sac-wall is a more reliable measure.

NEURALGIA OF THE MAMMARY GLAND—MASTODYNIA.

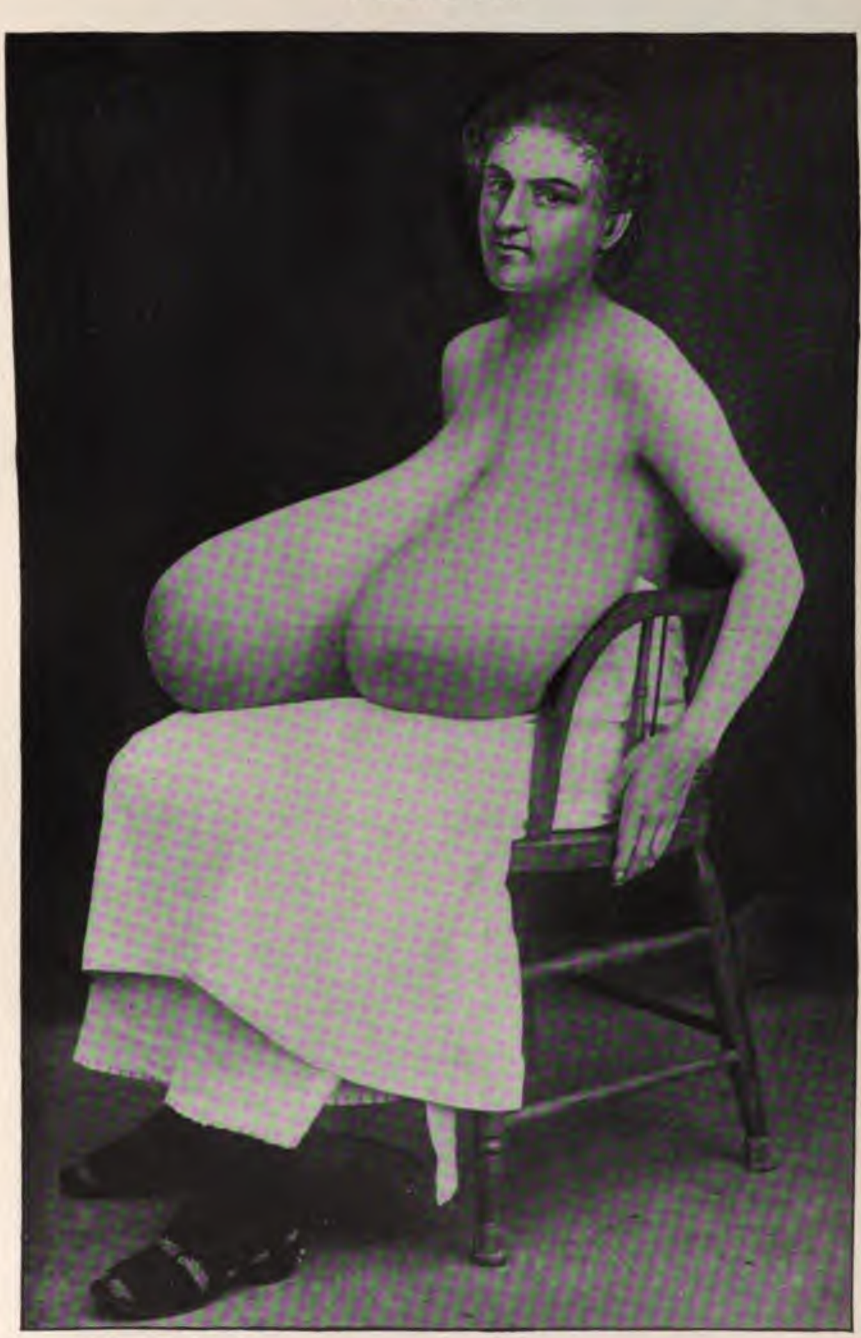
The neuralgic pain occurring in one or both breasts may be of varying origin. In some cases no abnormality of the breast can be found. The nervous, hysterical women complain of intense pain that resembles an electric shock passing through the breast, shoulder, and down the arm. Sometimes there is hypersensitiveness of the skin of the breast, so that even the slight pressure of the clothing cannot be borne. These neuralgic pains are frequently observed in people with disturbances of the genital organs that should be attended to if possible. Sometimes the pain is due to intercostal neuralgia. In other cases small hard, indurated areas in individual lobes of the breast may be found in women otherwise healthy. These are neurofibromata, and the pain is usually local. During menstruation the symptoms increase, and the nervous excitement may be so great that the women are unable to lie on the affected side at night.

Treatment.—The treatment should be that of the primary cause. If there are small nodules adherent to a sensory nerve, producing neuralgia, the growth should be removed. In women with disturbances of the pelvic organs the pain in the breast will disappear when the former conditions are improved. Local treatment will be of little avail in nervous, hysterical individuals and in those neuralgias in which the cause cannot be made out. One should direct applications of ice, poultices, suspension of the breast, quinine, iron, arsenic, electricity, change of climate, and try to influence the psychological condition of the women, who usually fear cancer of the breast.

HYPERTROPHY OF THE MAMMARY GLAND.

Hypertrophy of the breast may be due to simple hyperplasia of the normal constituents of the mammary gland—*i. e.*, of the connective tissue and gland itself. Benign hypertrophy involves both breasts and occurs at puberty or in young women pregnant for the first time. The breast rapidly increases in size for several months and then ceases to enlarge. It is uncommon to see the breast so large as to interfere with the daily occupation of the woman. When the size is excessive, there will in all probability be found some fibrosarcomatous nodules, as emphasized by Billroth. Amputation of the breast should be considered in these cases. If women with hypertrophied breasts become pregnant, the organ becomes extremely large, painful, and tense. The women may become so emaciated that an abortion is indicated. It is not desirable that these women should nurse their children, because it interferes with rapid involution of the breast. Sometimes the

PLATE XX.



Diffuse Hypertrophy of Both Breasts. (Porter.)

enlargement may be due to diffuse lipomatosis. There is abnormal overgrowth of fat and connective tissue, subcutaneous tissue, and intra-acinous tissue without involvement of the gland tissue itself, which may even be atrophied. Retromammary lipoma may resemble hypertrophy. Hypertrophy of one breast is always suggestive of a new growth.

Treatment.—Iodine and the thyroid extract have been used with success. Triper recommends the faradic current, and claims to have produced distinct diminution in the size of overdeveloped breasts by this method after three or four months. Michel performed mastopexy for painful hypertrophied breasts. He removed a half-moon-shaped section over each breast. The concavity of the incision was directed downward. The incision was carried through the skin and aponeurosis of the pectoral muscle, and the breast fastened to the pectoral fascia by sutures that passed through the gland-substance. The result was said to be good. Sometimes the male breasts do not cease to develop and enlarge just as those of women (gynæcomastia). According to Stieda, there is hyperplasia of all the elements of a normal male breast—first of all the connective tissue, the then fat and glandular tissue.

TUMORS OF THE MAMMARY GLAND.

Tumors of the mammary gland, especially in women, are extremely common and vary greatly histologically. Almost all the known varieties of tumor have been observed in this region and, although the various growths are of extreme interest pathologically, only the chief types will be considered, the clinical peculiarities of which make them either benign or malignant. The neoplasms will therefore be subdivided into two large groups. This method of distinguishing tumors is not absolute, because some new growths are distinctly benign in the early stages, but undergo malignant degeneration later. The benign nature of mammary tumors therefore is relative, and early operative interference is justified in all cases.

Benign tumors usually consist of some tissue that resembles the normal tissue of the breast. They are homogeneous as compared with the heterogeneous tumors. The former group includes all connective-tissue tumors with fibroma and all its combinations, and of the epithelial tumors, the adenoma with its combinations with the connective-tissue group. To the latter variety belong the connective-tissue tumors the sarcomata, and of the epithelial tumors the carcinoma. This method of subdividing tumors is not practical because enchondromata of the breast, for instance, are heterologous, but are benign. The benign growths are circumscribed, sharply outlined, and displace the neighboring tissues mechanically. The malignant tumors infiltrate the neighboring tissues and destroy them. Only the benign mammary tumors are movable within the breast. The rate of growth is of great diagnostic and prognostic significance. The more rapidly a tumor increases in size, the greater the proportion of its cellular elements. The tumor is softer and more vascular. Small portions of soft tumors may be easily torn off and carried away by the blood-current or lymphatics. Metastatic growths indicate the extremely malignant nature of a tumor. These are found early in carcinoma, for the lymph-glands in the vicinity may be involved before metastases in distant organs can be detected. Malignant tumors produce general exhaustion and cachexia. The fine anatomical differences in the histology of these tumors is not of clinical importance and bears no relation to the clinical picture. The author will not consider the variation from the structure of normal types, and will consider the clinical picture produced by the chief variety. The first question that will have to be decided is, whether the tumor is benign or malignant, and whether it should be removed immediately or can remain without damage to the patient. The diagnosis of typical cases will not be difficult as a rule, whereas variations from the chief types may give rise to uncertainty in the early stages. In these doubtful cases an exploratory incision should be done so as not to be too late with radical interference in malignant growths.

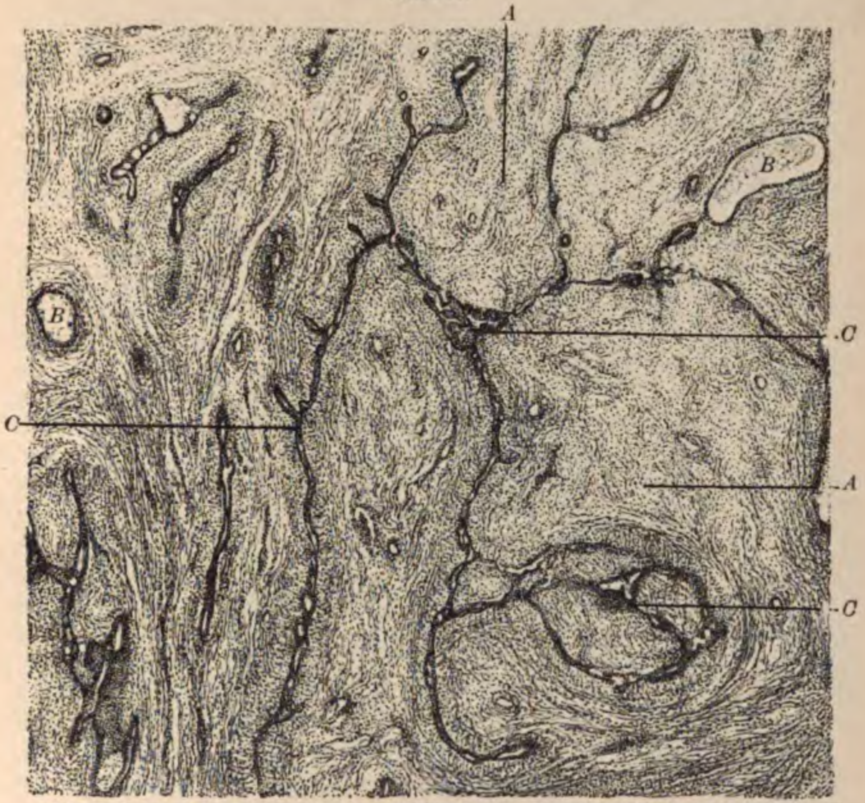
Fibro-adenoma (**Cystosarcoma Phyllodes; Myxoma Intracanaliculare; Cystosarcoma Proliferum**).—The ducts of the gland are surrounded by connective tissue which is especially developed in the mammary glands of virgins and appears as a dense hyaline mass with abundant nuclei. This connective tissue is the seat of origin of all fibroma and sarcoma of the mammary gland. Pure fibromata of the mammary gland are extremely rare, as are also pure adenoma. Fibro-adenoma is more common, and is, as it were, the only representative of benign tumors of the breast.

Fibro-adenoma consists of dense connective-tissue stroma and cellular elements, resembling the normal gland-substance of the breast. Between the epithelial masses is found more or less connective-tissue stroma. Sometimes the connective tissue predominates, sometimes the glandular substance, and the arrangement may vary greatly even in one and the same tumor. One portion may be distinctly fibroma, and another distinctly adenoma. Certain authors maintain that the connective-tissue portion is sarcomatous and apply this name to the tumor. The ducts become elongated and the acini enlarged, but remain narrow, which gives rise to the cystic clefts of Schimmelbusch, so characteristic of fibro-adenoma. According to this author, this method of growth explains the peculiar appearance of these tumors. The epithelium of the acini remains as a single layer of cylindrical epithelium. In firm fibro-adenomata the connective tissue is a fibrous spindle-cell mass, whereas in the softer and more rapidly growing variety it has the character of loose myxomatous tissue. The periacinous regions are those with the greatest number of cells, and Schimmelbusch assumes that growth takes place at these points. Adenofibromata therefore are glandular tumors with marked proliferation of connective tissue.

The tumors described by Johannes Müller as cystosarcoma phyllodes, and by Virchow as intracanalicular myxoma, are, according to

Schimmelbusch, fibro-adenoma, because the lobulated cauliflower-like appearance of individual tumors is not due to a growing in of fibrous masses in already existent cysts and dilated ducts. If the fibrous tissue infiltrated the tumor in this way, the epithelium would disappear and become atrophied, which is not the case.

FIG. 211.



Fibro-adenoma of mammary gland: *A*, fibrous tissue: *B*, preserved lumen of gland-ducts; *C*, glands, the lumen of which is almost obliterated by the pressure of fibrous tissue on the outside.

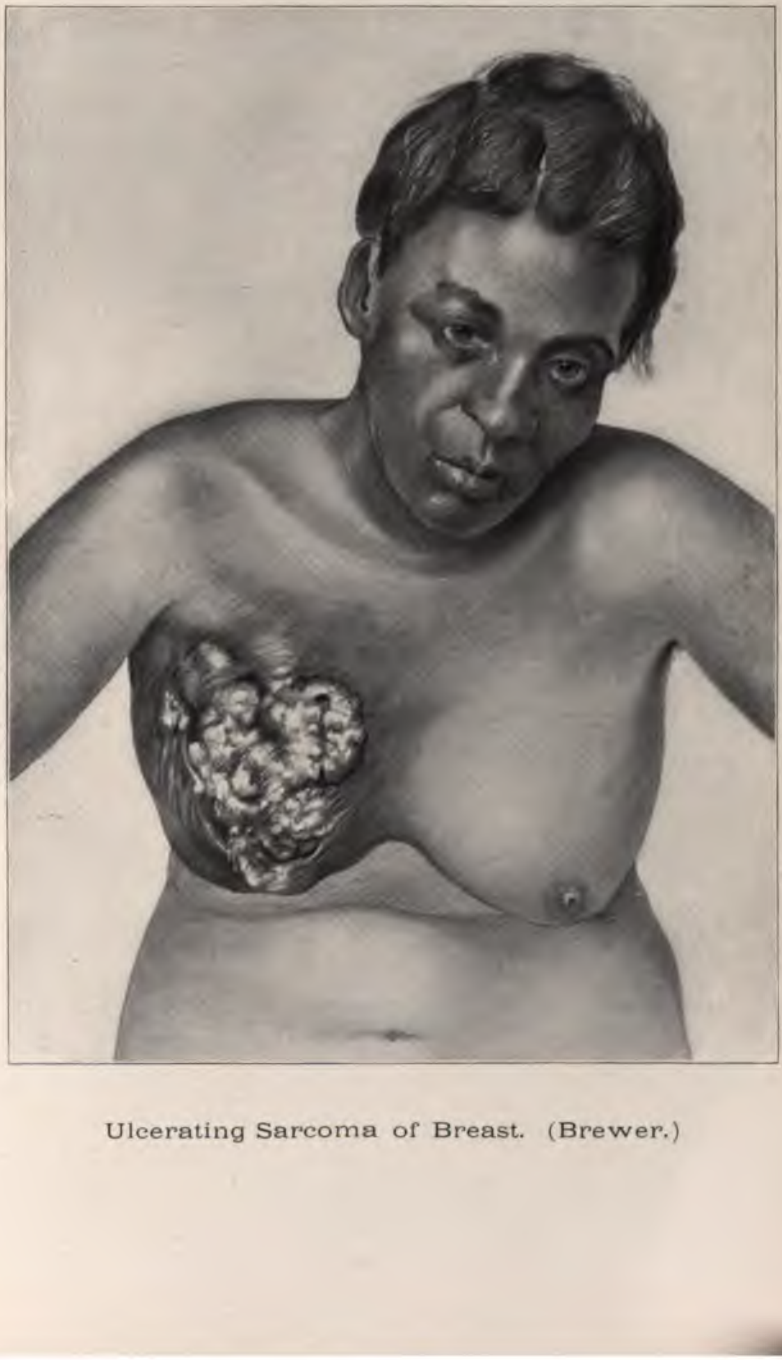
The ducts and alveoli are preserved and may even increase in size. The epithelium may show evidence of marked proliferation. When the glands produce a mucoserous secretion, the ducts become distended and cysts appear. The periglandular connective tissue develops irregularly and encroaches upon the distended canals and alveoli, producing polypoid or flat excrescences (intracanalicular fibroma, Ziegler; or cystosarcoma prolifera, Billroth). These flat overgrowths of connective tissue preserve the lobular appearance of the tumor and give it the outward look of a cauliflower. On section the tumors are grayish white, smooth, homogeneous, and more or less lobulated. Fibro-adenomata occur chiefly between the twentieth and thirtieth year of life. They are uncommon after forty. As a rule they cause no pain. The size may differ considerably, and varies from that of a hazelnut to that of a man's head. In the latter case the extreme size is due to the formation of cysts. Many fibro-adenomata remain small for years and then suddenly increase in size. The most important clinical criterion of these tumors is that they are encapsulated in a firm connective-tissue mass. This is the reason why they are so easily moved, especially when they are superficial. Sometimes they may not appear to be in any way connected with the mammary gland, and as long as they remain small they are firm and hard; those of larger size have soft areas. The tumors are usually round with a smooth surface, or sometimes irregular and lobulated. They never become adherent to the skin nor to the underlying fascia or muscle. The glands belonging to this region never become enlarged. Even when they have persisted for a long time they do not rupture the capsule and infiltrate the surrounding tissue.

Treatment.—The treatment is operative. Although fibro-adenomata are distinctly benign growths that do not form metastases, they may produce grave disturbances by their growth. When small, the capsule and overlying gland-tissue may be divided and the nodules shelled out with a closed pair of scissors or with the finger. Any communication with the gland-tissue present may be divided with a knife. Larger tumors that have obliterated the mammary gland on account of pressure should be amputated with the breast. Kocher recommends turning up the breast and enucleating benign tumors subcutaneously. A curved incision with the concavity upward is made along the inferior margin of the breast. This is carried down to the pectoral fascia and the gland separated from this and dissected free from the skin. Partial excision of deep-seated tumors may be done in the same way without involving the healthy gland-tissue.

Adenoma.—Pure adenomata—that is, tumors of gland-substance only—are uncommon. Häckel describes a case of this sort in a woman twenty-five years old. She had had her first child three months previously, but had noticed the tumor for six or seven years. This mass was the size of a goose-egg, did not cause pain, and was moderately firm. It could be easily shelled out because of the smooth connective-tissue capsule. On section the neoplasm resembled the cut section of a parotid gland or pancreas. The lobulated appearance was very distinct. In the interior of the tumor was a hollow space into which round ducts opened, from which a cream-like fluid, resembling a fatty emulsion, could be squeezed. Adenomata may lose their benign character and become carcinomatous. Besides fibro-adenoma, they may be combined with myxomatous tissue and develop cysts (adenomyxoma, adenocystoma).

Myxoma, Angioma.—These tumors are extremely uncommon in the breast. Fibromyomata are relatively more common. Clinically they do not differ from fibro-adenoma, and at times cannot be differentiated.

PLATE XXI.



Ulcerating Sarcoma of Breast. (Brewer.)

Lipoma.—Lipomata of the breast are also uncommon. Those occurring in this region are usually situated behind or at the side of the breast and displace the latter. The author excised a lipoma the size of a fist which developed along the lower margin of the pectoral muscle toward the axilla and displaced the breast upward and inward. It was impossible to find any line of demarcation between the mammary gland and the lipoma. Billroth describes a case of retromammary lipoma which was of unusual dimensions. Similar cases have been reported by A. Cooper and Velpeau. Begonin and Häckel have each described one true lipoma of the mammary gland which contained ducts within the fatty tissue.

Chondroma, Osteoma.—Chondroma of the mamma is extremely rare. It is of somewhat more frequent occurrence to find cartilage in the mixed tumors. Bony tissue is found only in few cases and is practically of no importance.

Sebaceous Cysts (Cholesteatomata).—Sebaceous cysts of the breast have been described in very small numbers. The cysts are characteristic with a thin wall, smooth interior surface like a mucous membrane, and contain a porridge-like mass consisting of fatty degenerated cells. Microscopically the cyst-wall consists of a thin connective-tissue membrane that is not sharply differentiated from the connective tissue of the gland. On its inner surface are several layers of epithelial cells. The individual cells are large and the peripheral layers have nuclei that stain readily. Häckel reports two cases of this sort, one of which was associated with cystosarcoma phyllodes. The cysts in the breast-tissue were sharply outlined and gave rise to pain only once in a great while, and were not influenced by menstruation. They were easily shelled out.

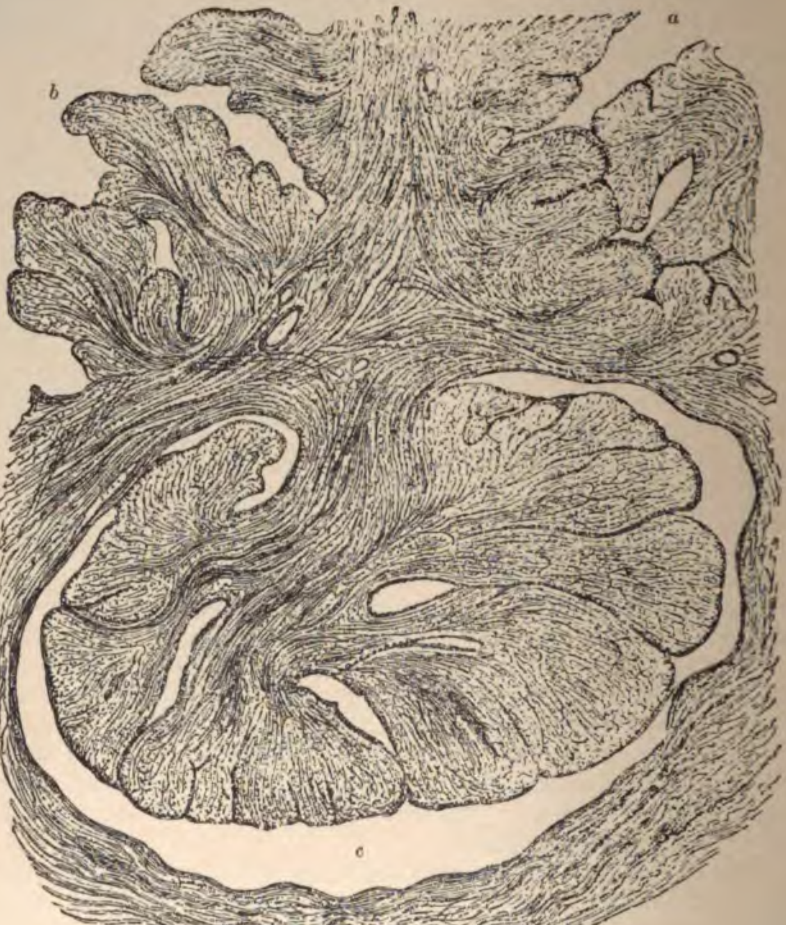
Sarcoma.—All sorts of sarcomata may develop in the breast, although they are more uncommon than carcinomata.

Of 355 tumors of the breast collected by Poulsen, only 33 were sarcoma—*i. e.,* 9.3 per cent.—and of these, 14 were cystosarcoma. Of 150 tumors operated upon in Czerny's clinic, 7.03 per cent. were sarcoma. Horner reports 172 malignant tumors of the breast, 158 of which were carcinoma and 14 sarcoma. In the author's clinic 359 tumors of the breast were reported by Gebele, 34 of which were sarcoma and 19 benign growths.

Gross reports 176 sarcomata of the breast: 68 per cent. were spindle-cell sarcomata, 27 per cent. round-cell sarcomata, and 5 per cent. giant-cell sarcomata. Half of the cases showed cystic degeneration. According to Gross, the spindle-cell and cystic sarcomata are found more frequently in the breast of functionating women—*i. e.,* in women in the third and fourth decades. They have a tendency to recur after removal. The giant-cell and more solid sarcomata appear after the physiological function of the breast has ceased, and are more apt to form metastases. Sarcomata appear at any time of life. The prognosis of soft sarcoma is more unfavorable than that of the hard variety and cystosarcoma. According to Poulsen, 42 per cent. of the former die of recurrences and metastases, and only 25 per cent. of the latter. Cystosarcoma and spindle-cell sarcomata usually develop slowly, whereas round-cell sarcomata may grow much more rapidly.

Schimmelbusch considers that many of the tumors described as cystosarcoma are really fibro-adenoma, because they are comparatively benign and never show any tendency to recur or form metastases. He considers true sarcoma only those growths consisting of connective tissue, the cystic spaces of which represent lymph-spaces or foci of softening, whereas the fibro-adenoma are glandular tumors with marked proliferation of connective tissue. Schimmelbusch's results do not apply to the group of tumors called cystosarcoma, occurring so fre-

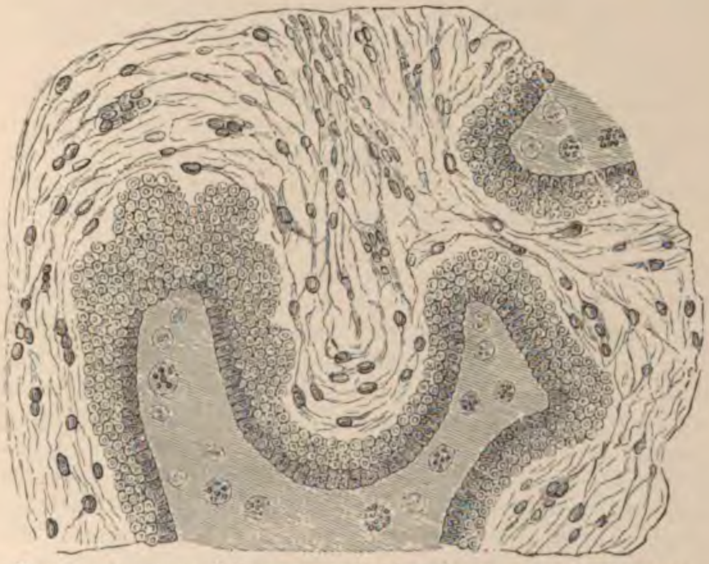
FIG. 212.



Proliferating cysto-sarcoma of the breast. (Billroth.)

quently, and the author will therefore devote especial attention to this group. These tumors were described by Johannes Müller as cystosarcoma proliferum phyllodes. The cut section is pale reddish or white, and the tissue is gelatin-like in places and appears œdematous. In other places it is fibrous. There are irregular cavities filled with thin mucus into which lobulated and polypoid masses extend. These cystic spaces represent altered ducts of the gland-lobules. The tissue itself is partly œdematous connective tissue, partly myxomatous lymphoid tissue. The epithelium of the ducts and acini consists of several layers of cylindrical epithelium. It proliferates in such a way that the cavities become entirely filled with epithelial cells. These may accumulate in small masses, called pearls, or become dissolved and form a homogeneous mass. These cystosarcomata develop usually in the third or fourth decade, are irregular tumors of uneven consistence, and fluctuate distinctly where the cysts are superficial. They have a distinct capsule and never become adherent to the pectoral muscles or to the chest-wall, or have any tendency to involve the mammary gland diffusely. They may develop and form tumor masses occupying the entire breast, which is, of course, followed by atrophy of the glandular portion due to pressure. (Figs. 212 and 213.) The overlying skin is tense, thin, and reddened, and may ulcerate. The overlying veins are distinctly enlarged. The nipple is retracted only in rare cases. These tumors sometimes exist as small affairs for years, when they suddenly without apparent cause begin to increase in size and may become enormous.

FIG. 213.



From a cystosarcoma of the mammary gland. Myomatous tissue. (Billroth.)

Soft sarcomata develop at any time of life and are usually single in one breast. In rare cases they may diffuse and involve both breasts. In the early stages they are present as firm, movable nodules, but enlarge quickly and become soft without causing especial pain. The axillary glands are involved only in rare cases, and usually in the later stages of the disease. The patients become quite cachectic at this time.

The most malignant sarcomata are medullary and melanosarcoma. They develop very rapidly, involve the surrounding tissue, and are apt to recur and form metastases after excision.

Diagnosis.—Even the most expert clinician will but rarely be able to diagnosticate small growths as sarcoma. They may readily be confounded with fibro-adenoma, cysts, or carcinoma. When the tumors are larger the diagnosis is always easy. The method of developing, the relation of the tumor to the neighboring tissue, the absence of pain and glandular enlargement, will oftentimes enable a correct differential diagnosis.

Treatment.—The treatment of all sarcomata, no matter what their histology, consists in radical removal. In the case of soft sarcoma the entire breast with the overlying skin should be removed, and it is sometimes questionable whether one ought not to clean the axilla. If the axillary glands are enlarged, this is indicated, but when no enlargement can be made out there may be reasonable doubt. Sarcomata usually extend through the blood-current. Lymphatic infection develops at a later period, although exceptions to this rule do occur. Experience shows that metastases in the adjoining lymph-glands are hardly ever developed after removal of sarcomatous breasts, and local recurrences are relatively uncommon if all tissue involved was removed at the time of operation. Metastases in the internal organs, especially the lung, the liver, and the brain, on the other hand, are much more common. According to the author's experience, it is necessary only in exceptional cases to clean the axilla, although he acknowledges that the operation is not especially more dangerous on account of this. It is his custom to extend the incision sufficiently toward the axilla to be able to determine the condition of the axillary glands. These may be readily palpated after dividing the skin in this region, and when enlarged should always be removed.

Small cystosarcomata may be removed with some of the surrounding tissue, which is sufficient and easy if the tumors are encapsulated. Statistics show that local recurrences may even follow circumscribed cystic sarcoma. It may be that portions of the tumor were left behind, or that new growths form in the remaining portion of the gland. A permanent cure is only possible by amputation of the breast, and is indicated in all doubtful cases.

A permanent cure is much more common after an operation for sarcoma of the breast than after one for carcinoma. According to Horner's statistics, 76.92 per cent. of the patients had no recurrences after two years. The total recoveries were 61.54 per cent.

According to Poulsen, 75 per cent. had no recurrences after five years, and 25 per cent. died of metastases.

Carcinoma.—Carcinoma is very common in the female breast. The uterus and the stomach are the only organs affected more frequently. In women carcinoma of the breast stands second in frequency. (Heimann.) The frequency of carcinoma of the breast is directly related to functional activity, because the mammary gland is intimately associated with the sexual apparatus. Development of the breast to its full functional capacity is associated with an increase and with new formation of gland-tissue, connective tissue, vessels, and lymphatics. No other organ of the body is so frequently subject to changing conditions of nutrition, and no other organ has such enormous demands placed upon its functions. Besides, there is in the mammary gland the continual change in development which is retrograde. This is in all probability the reason for the frequency of carcinoma of the breast, because before puberty mammary carcinomata are almost unknown.

According to Billroth's statistics, containing 440 cases, 82 per cent. of all tumors of the breast are cancer. Schmidt, in Heidelberg, found the percentage to be 82.66; Bryant, 83.16; Gross, 82.47. In the author's clinic, of 359 tumors of the breast, 306 were carcinoma —*i. e.*, 80.9 per cent; 34 were sarcoma—*i. e.*, 9.1 per cent.; and 19 were benign growths.

There is a noticeable increase of cancer in all countries. In Prussia 2.66 of 10,000 inhabitants died of cancer in 1877; in 1896, 5.53. In Austria the corresponding figures were 3.7 and 6.3. In England there died of cancer in 1860, 3.17; in 1895, 7.55. In London, in 1860, 4.2; in 1896, 8.8. According to R. Williams, the relative death-rate of cancer in England at the present time is four times as great as fifty years ago, and in Prussia the death-rate has increased 153 per cent. since 1877. In Bavaria the percentage increased 105.5 per cent. from 1890 to 1899; 8.3 per cent. in males and 102.2 per cent. in females. It is not known why the mortality from carcinoma has increased in this manner. Certain authors consider that the increased amount of meat eaten and the increased consumption of alcohol and over-eating are responsible. Benecke believes that a vegetable diet prevents to a certain degree the development of cancer. On the other hand, Hendy reports that of 102 cancer cases operated upon by him, 61 were strict vegetarians. Herbivorous animals are far less liable to cancer than carnivorous animals. Hogs are almost immune. Frick has proved that individuals whose time is occupied with preparing and selling alcoholic beverages are much more frequently affected than others. None of these hypotheses are sufficiently proved, nor are they sufficient to explain the increase of cancer; besides, it is questionable whether this increase is actual or apparent, and whether the more frequent autopsies and more accurate diagnosis make it seem as if the condition was on the increase. Medical geography has shown that in England carcinoma is more common in depressions with abun-

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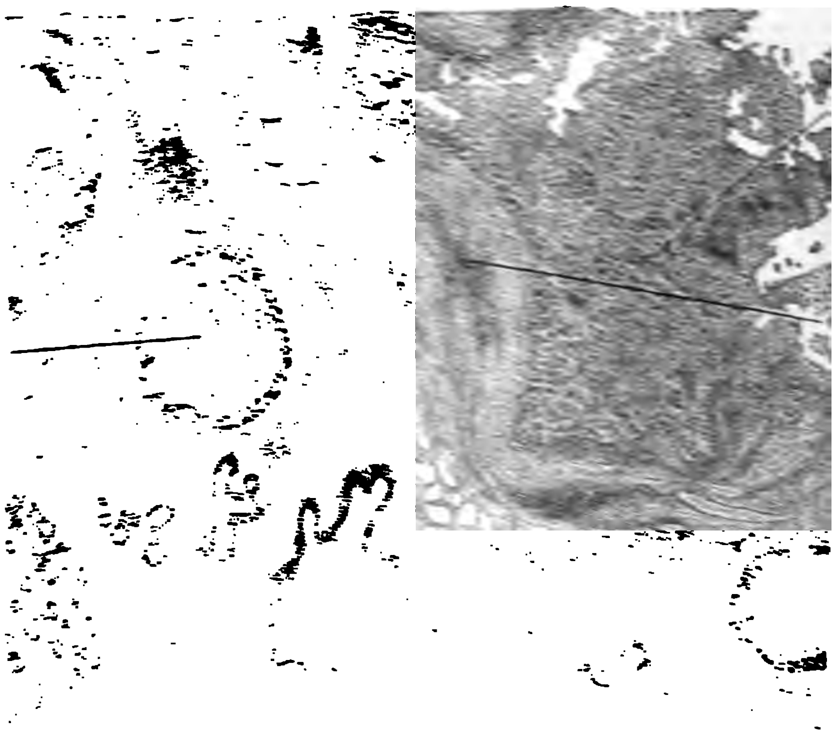

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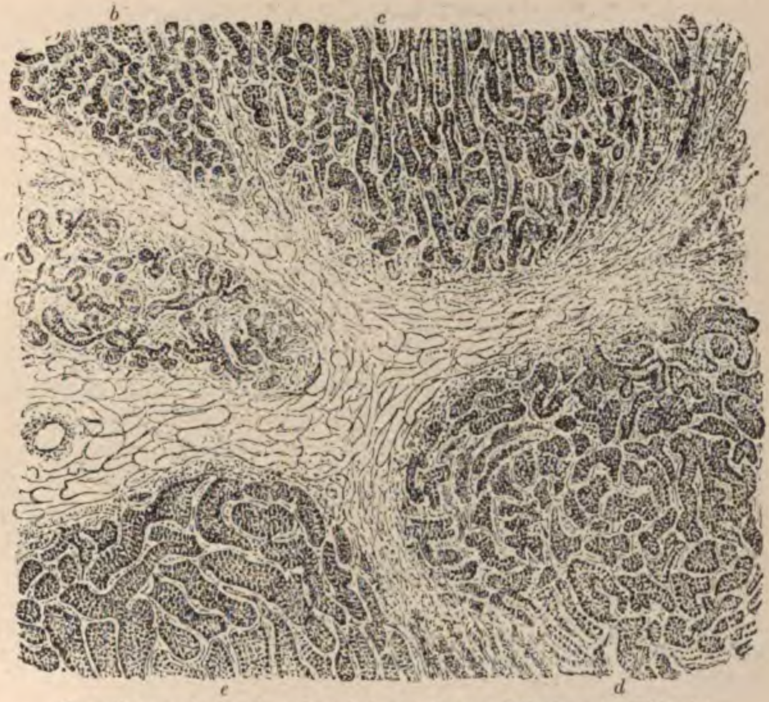
and ulcers develop covered with flabby granulations. The disintegrated portions form a bright-yellow gruel-like mass.

TUBULAR CARCINOMA.—This is the most common variety. It is characterized by the development of elongated ducts or tubes filled with epithelial cells which soon extend beyond the bounds of the original acini. They are apt to extend laterally and infiltrate the surrounding tissues. The nests of cancer-cells are elongated, tube-like accumulations. Cellular infiltration of the connective tissue goes hand in hand with the proliferation of epithelium. Later disconnected nodules are found in the surrounding skin, fat, muscle-tissue, and pleura. The skin of the chest and back and arms may be covered with innumerable hard nodules (cancer en cuirasse, panzerkrebs). The skin itself is board-like, inflamed, and immovable. Disintegration takes place much more slowly in tubular infiltrating cancers than in the acinous variety. The detritus is in part carried away by the veins and the dense connective tissue surrounds the remaining portion. An interstitial scar (Billroth) develops, which may be recognized by retraction of the skin and nipple.

FIG. 215.

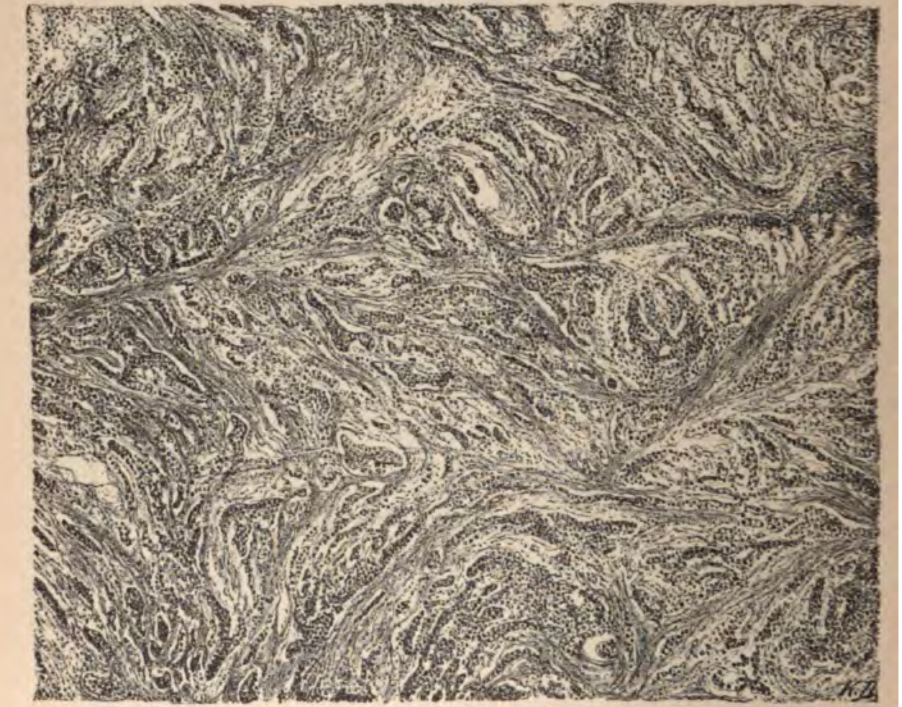


From the marginal region of a tubular carcinoma of the breast. (Billroth.)

SCIRRHUS.—This form of tumor develops slowly, and is associated with disappearance of the cancer-tissue and subsequent fibrous contraction and induration. The tissue creaks when cut. The connective stroma predominates and the cell-nests are small and few. Microscopical examination shows an abundance of elastic fibres and tubular nests of cancerous tissue. This form of tumor is found most frequently in old women.

GELATINOUS CARCINOMA.—Gelatinous cancers are uncommon. Lange collected 75 cases up to 1896, and of 1814, only 0.93 per cent. were of this variety. The gelatinous, slimy nature of the cut surface is evident microscopically. Transparent masses are embedded in a framework with abundant spaces. The gelatinous material, according to Lange, owes its origin to disintegration of strands of cancerous tissue, surrounded by connective tissue. This destruction goes hand in hand with the disappearance of cancer-cells, which may sometimes be found only in the more recent portions. This form of cancer develops slowly, and the prognosis is the best of all cancers of the breast.

FIG. 216.

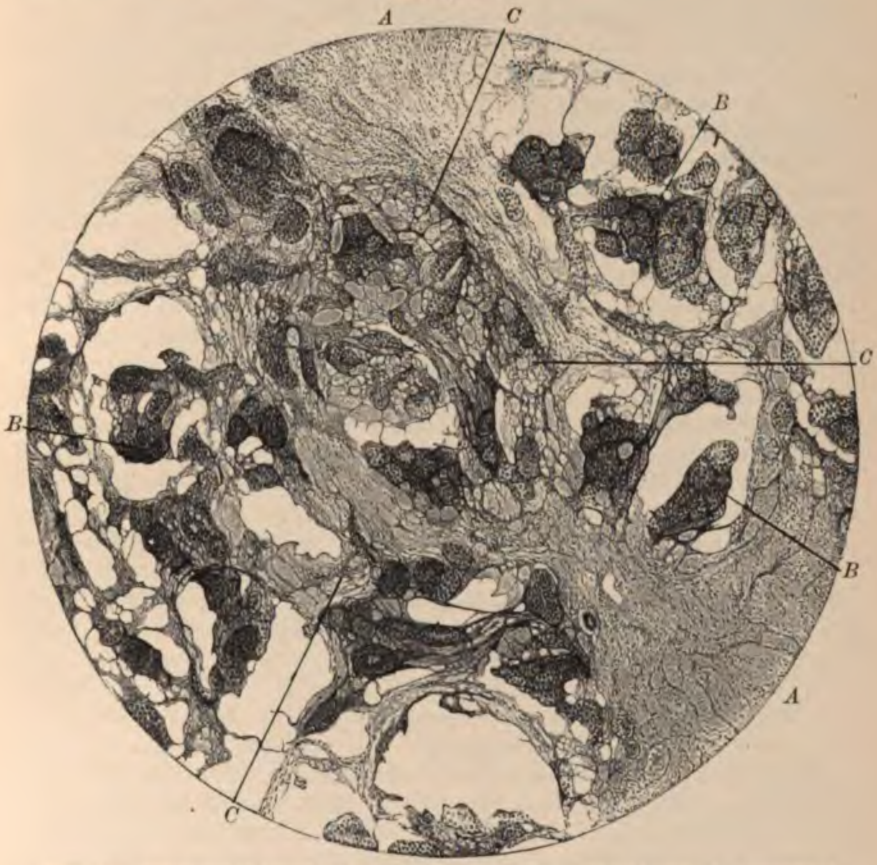


Scirrhus of the breast: predominance of fibrous tissue with rows of cuboid or polygonal cells, some of them single.

The psammocarcinomata described by Neugebauer are a special variety of cancer of the breast. Chondro-osteocarcinomata have also been observed.

The cut section of carcinoma is usually reddish-gray or whitish and traversed by several paler and firm net-like strands of connective tissue, between which the softer tissue is embedded. The cancer is usually not encapsulated, and may be more or less distinctly outlined against the surrounding gland-tissue, or appear as scattered nodules or as a diffuse infiltration. The so-called cancer-juice can be squeezed out of the cut surface of the tumor with a knife. Microscopically this consists of detritus and large epithelial cells with large nuclei and refractile nucleolar granules.

FIG. 217.



Gelatinous carcinoma of breast: *A*, stroma with vessels; *B*, epithelial nests; *C*, degenerated masses of epithelium with most of the nuclei gone.

Etiology.—The primary cause of cancer of the breast is no more known than is that of cancer in other regions of the body, and the author will only consider in this connection the conditions that seem to be predisposing from a practical standpoint.

Cohnheim's hypothesis, that cancer is due to fœtal predisposition, does not apply in the case of cancer of the breast, because these can be proved to develop from the glandular epithelium. Ribbert claims that carcinomata are due to separation of epithelium from their respective connective tissue, produced by proliferation of the subepithelial connective tissue. This is supposed to separate the glandular epithelium from its normal support. The cells do not lose their peculiarity of increasing, and develop in the directions where they find the least resistance—*i. e.*, into the tissue-clefts, the lymph-spaces, and around the vessels. This theory is plausible, although it has met with considerable opposition, especially by Hauser, who demonstrated that in carcinoma of the breast there was cancerous degeneration of the gland epithelium, while the membrana propria remained intact. The parasitic nature of cancer has not been proved. Not one of the cancer parasites described up to the present day has withstood scientific criticism. It has repeatedly been possible to transfer cancer from one animal to another, which, however, does not prove the infectious nature of the disease. Sometimes during an operation portions of cancer are transplanted. It has been shown that sporozoa, coccidia, and similar bodies may be found in carcinoma of the breast, but they are not the primary cause, because they are not present in the metastases. They might possibly produce chronic inflammatory processes in the gland-tissue, and indirectly favor the development of cancer. Carcinoma is not contagious, and one person cannot become infected from another. Of German surgeons defending the parasitic theory, there is to be mentioned Czerny; and of the Americans, Park and Dennis.

Numerous cases of carcinoma of the breast are known in which the tumors developed after some sort of irritation (trauma), followed by chronic inflammatory processes. The irritation theory is based upon this fact, but it is not a satisfactory explanation for all cases.

The etiology of carcinoma of the breast is not uniform, but depends on a variety of causes. The accidental causes will be first considered. Mastitis and chronic inflammation are of importance. The largest percentage of cancers occurs in women that have nursed. Modern statistics show that of 1298 cases, 142 were in women with previous mastitis. Of 236 cases observed by Billroth, 23 were unmarried—*i. e.*, 9.74 per cent. Velpeau's statistics show that of 218 cases 25—*i. e.*, 15.34 per cent.—were unmarried. Of 158 cases in Zurich, 142 were married and 16 unmarried. Of the married women, 11 had had no children. The Statistical Bureau of Prussia showed that in 1895 to 1896 57 per cent. of the women with cancer were married and 25 per cent. widows or divorced, and 17 per cent. unmarried. About 10 to 16 per cent. of all cases of carcinoma of the breast occur in sterile women. Of 306 cases treated in the author's clinic between 1890 and 1899, 229 were married (74.8 per cent.), and 77 unmarried (25.2 per cent.), and 151 (49.3 per cent.) had had children, and 62 of these (41 per cent.) nursed their babies, while 31 (20.5 per cent.) had had mastitis. The number of women that nursed and had cancer was small as compared with other statistics, which is explained by the fact that in this region the women rarely nurse their children, a practice that explains the high death-rate among the infants. Of 552 women treated in v. Bergmann's clinic for carcinoma of the breast, 500 (90.5 per cent.) had given birth. Of 389 women, 289 (74.2 per cent.) had nursed, and 16.4 per cent. of all the patients had suffered from mastitis.

One fact is plain from the above statement, namely, that mammary glands that have developed to their full physiological capacity are more prone to carcinoma, and that fertile women are more frequently attacked by mammary carcinoma than the sterile ones. The influence of nursing is much more important than sexual intercourse and conception, and there is no doubt that only a small number of women with late carcinoma have not nursed.

Chronic inflammation favors the development of carcinoma. Attention is called to the chimney-sweep's carcinoma, carcinoma of old scars and following chronic metritis. Continuous mechanical irritation is also of etiological importance, such as the pressure of tight corsets. Certain women have a habit of steadying their work against the breast. Not infrequently a single trauma has been given as the primary cause of cancer. Ziegler investigated the influence of trauma on the development of malignant growths, and found that of 170 cancers of the breast, there was a history of trauma in 37 cases—*i. e.*, in 22 per cent. Gebele found a history of trauma in 18.6 per cent.; Guleke, in 7.3 per cent.; Williams, in 44.6 per cent.; and Löwenthal found a history of injury 125 times in 934 cases of cancer of the breast—*i. e.*, in 13.4 per cent. Snow found a history of trauma in 11.5 per cent. of 9600 cases of carcinoma of the breast. There is no doubt, although the connection cannot be explained, that a single contusion of the mammary gland may be the predisposing cause for the development of cancer, especially when the trauma occurs at a time when the woman is liable to carcinoma. The injury produces an extravasation of blood which remains as a small indurated focus, furnishing the nidus in which a carcinoma develops. Every surgeon is acquainted with cases in which the carcinoma developed at the seat of injury. The influence of trauma is emphasized especially in the cases of neoplasms that develop in regions of the body that have no special predisposition to the formation of tumors.

According to Winiwarter's statistics, 6 per cent. of the carcinoma were hereditary; Breutigam, 8.5 per cent.; Bryant, 10 per cent.; Horner, 17.09 per cent.; Pfeiffer, 9.3 per cent.; Zahn, 10.5 per cent.; Guleke, 16.5 per cent.; and Gebele, 5 per cent. The author mentions in this connection Broca's interesting communication, in which of 26 individuals belonging to three generations, 16—*i. e.*, 61 per cent. —died of cancer, and 10 of these of cancer of the breast. According to statistics, heredity plays an unimportant part considering the frequency of the disease. There is no doubt, however, that certain families are predisposed to cancer, as every practitioner is aware. Roger Williams believes that hereditary cancer usually attacks the corresponding portion of the body.

The influence of age in cancer of the breast is evident. Th largest number of cases occur between the forty-sixth and fifty-fir year of life—that is, around the menopause, which is the period whe the breast undergoes retrograde changes. Carcinomata of the breas occurring during the early years of life are usually very malignant According to Horner, the average age of women affected with car cinoma of the breast was 51.45 years; Winiwarter, 45.3; Gebel 50.8; Guleke, 49.2; Oldekop, 48.4; Fischer, 46.9; Schulthess, 49 Carcinoma of the breast is extremely uncommon before puberty, an about 40 to 46 per cent. of the cases occur after the menopause. O 306 women with cancer of the breast treated in the author's clinic, 11 were between forty and fifty years of age, and 77 were between fift and sixty years of age.

According to Williams, race has a certain amount of influence, an white women are twice as frequently diseased as negroes. Accordin to him, the women in the better classes of society are more frequentl affected than those of the poorer classes.

Anatomical Distribution.—Cancer of the breast may develop i continuity or in disconnected masses. Prolongations of a cancer ma infiltrate the surrounding tissue, involve lymph-spaces, bloodvessels and lymph-vessels. Langhans demonstrated that epithelial cells fro carcinoma of the breast could be carried for considerable distances i the lymph-vessels, and that there is no doubt that metastases develo especially through the aid of the lymph-current. Later, when th carcinoma has infiltrated the walls of veins, the cancer-cells may b distributed by the blood-current.

Accurate investigations of the anatomical distribution are due t the efforts of Heidenhain, Gerota, Grossmann, Stiles, Rotter, an Oelsner. It is evident that the lymph-glands which receive th lymph-vessels from the breast will be the first affected. These are th glands of the axilla, which receive the greater portion of the lymp from the breast. When these are involved, the lymph backs up i the peripheral channels and is obliged to take a course which up t this time was little developed. Unusual anastomoses are formed in this way. Gerota injected the lymph-vessels coming from the mammary gland which emptied into a gland at the lower margin of the breast, in the region of the lateral twig of the long thoracic artery. He then injected the lymph-channels accompanying the second and third perforating branches of the internal mammary, and showed how metastases might develop in the retrosternal glands. He furthermore proved that the respective halves of the chest did not have an independent lymphatic system, but that the lymph-capillaries in the skin of the chest, abdomen, and back were intimately connected. This explains extension of a carcinoma of one breast to the other. Grossmann injected a lymphatic vessel which passed from the breast to the posterior surface of the pectoralis major along with the superior thoracic artery, and after passing through two or three lymph-glands communicated with the infraclavicular group. This lymph-vessel communicated on the anterior surface of the pectoralis minor with the first axillary glands.

Heidenhain, in 1889, called attention to the fact that after amputation of the breast and cleaning out the axilla, as recommended by Volkmann, recurrences in the axilla were extremely rare, although local recurrences were frequent. Schmid reports 74.74 per cent. and Rotter 88.23 per cent. of local recurrences. Heidenhain found that the reason for this condition was that after amputation of the breast a portion of the gland or of the cancer remained on the surface of the muscles. In the retromammary fat there are, besides the bloodvessels, lymph-channels which contain microscopical metastases in two-thirds of the cases. If the pectoral muscle itself is cancerous, the contraction will force the epithelial cells in the muscles into the lymph-current. Heidenhain recommends when the cancer is movable to remove a continuous layer of the upper surface of the muscle, and to exercise care not to tie the bloodvessels outside of the muscle, but in the muscle itself. If the carcinoma is adherent to the fascia of the muscle, the muscle should be removed *in toto* with the connective-tissue on its under surface. The infraclavicular fossa will be exposed in this way and excision of the clavicular glands is facilitated. Heidenhain recommends that the insertion of the muscle to the clavicle and sternum should be separated subperiosteally, because nodes of recurrence are especially common near the sternum.

Rotter's anatomical investigations throw light upon the manner in which metastases of carcinoma of the breast develop. These investigations corroborate Grossmann's observations that the retropectoral glands may be involved early in carcinoma of the breast without there being any nodules in the muscles or in its fascia. This means that cancer-cells are carried directly from the primary focus through the retromammary fat and muscles of the chest to the pectoral lymph-glands. Rotter showed by carefully prepared specimens that twigs of the superior thoracic artery with their accompanying lymphatics pass directly through the pectoral muscles into the parenchyma of the glands, and that in carcinoma of the breast lymphatic nodules along the posterior side of the pectoralis major might appear very early. This author found these retropectoral glands enlarged in about one-third of the cases, and concludes that the sternal portion of the pectoral muscles should always be removed in operations for cancer of the breast. The clavicular portion may be left unless there are infraclavicular glands enlarged. As long as these retropectoral glands may become infected so early before the cancer is adherent to the muscles or its fascia, it is reasonable to suppose that the malignant growth may extend quite early through the intercostal spaces to the pleura. This explains the unsatisfactory results after the most careful operation.

The investigations of these authors have been corroborated of late by Oelsner's work on the lymph-channels of the breast in their relation to the extension of carcinoma of the mamma. Oelsner injected the normal lymphatics of the breast, and showed that the trunks fro the anterior region run toward the anterior thoracic lymphatics alon the margin of the pectoralis major. They have secondary commun cations with the posterior thoracic group or with the intermedia group. The mammary gland itself sends two or three large lym phatics to the group of glands situated along the margin of the pector muscle in the second or third intercostal space, and from these to th subpectoral and subclavicular glands and subclavian trunk. Th lymphatic vessels found plugged with cancer-cells by Heidenhai Rotter, Halsted, and Stiles, were the normal lymphatics perforating th pectoralis major and intercostal muscles. These were shown to b

Fig. 218.

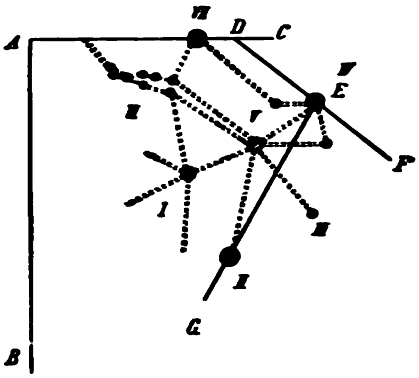


Diagram of axillary lymph-glands (left): *AB*, sternum; *AC*, clavicle; *DF*, axillary vei *EG*, long thoracic vein. Axillary glands: *I*, anterior thoracic glands; *II*, inferior thorac glands; *III*, posterior or subscapular glands; *IV*, superior or brachial glands; *V*, intermedia glands; *VI*, subpectoral glands, subclavicular glands; *VII*, supraclavicular glands. (Oelsne

present by Oelsner by injections, as were also the lymphatics accom panying bloodvessels close to the sternum in the first four intercost spaces. These communicated with the sternal glands in the interio of the chest. (Figs. 218 and 219.)

Recurrences may develop from bits of cancerous gland-tissue le at the time of operation. When dissecting off the skin, one no infrequently meets small advanced glandular nodules immediatel beneath the skin or on the pectoral fascia. Volkmann called attentio to these prolongations of gland-tissue, and there is abundant evidenc that these may extend as far as the sternum, the clavicle, or to th axillary line. Great care must be taken while operating on cancer o the breast to remove the entire gland. Recurrences may also develo from microscopical cancer-nests that are in the retromammary fat eve at the time of operation. Heidenhain and Stiles have shown tha carcinomatous emboli may become lodged a considerable distance from the primary focus. A cancerous breast may contain nodules of disease throughout the entire gland at an early stage—*i. e.*, it is diseased *in toto*, and the lymph-vessels leading from the gland may be involved very early. The majority of recurrences make their appearance within the first three months after operation; according to Winiwarter, in 82.4 per cent. of all cases. Recurrences become progressively less after the first half year. The cancer usually reappears in the scar itself or in the immediate vicinity as small nodes beneath the skin, in the muscle, or on the perichondrium of the ribs. These nodules are movable. Recurrences in the axilla after the usual method of operating are uncommon. All recurrences are probably due to cancerous cells that had been left behind, even though they remained latent for months. It seems to the author that local recurrences are not due to infection with cancer-cells at the time of operation. One cannot deny, however, that this may be possible. Metastases appear in the internal organs later just as in the cases not operated upon. The liver, the lungs, and the bones, especially the femur and humerus, are usually

FIG. 219.

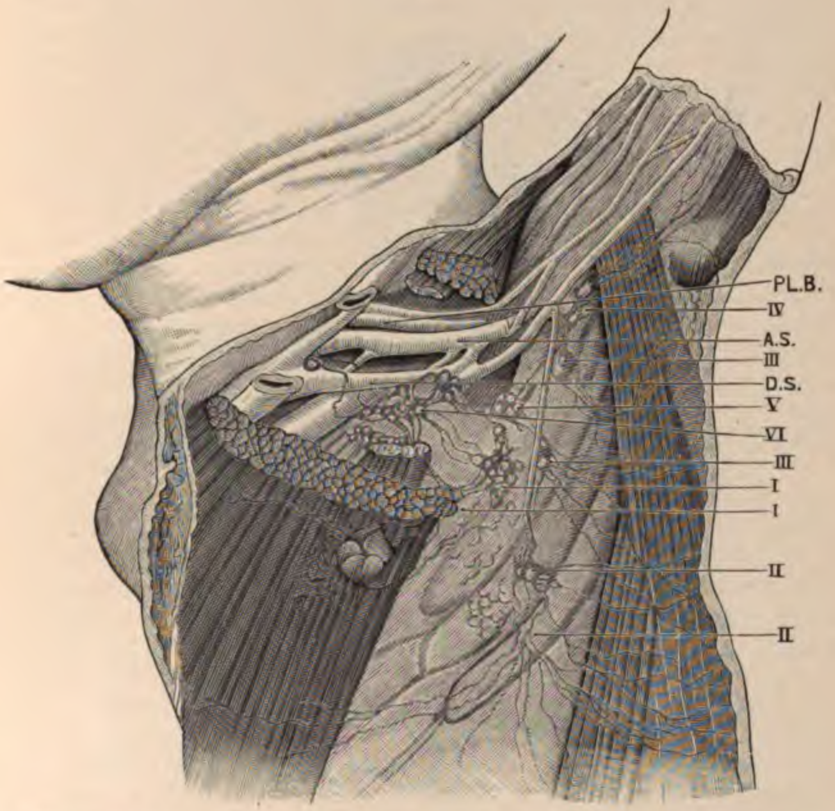
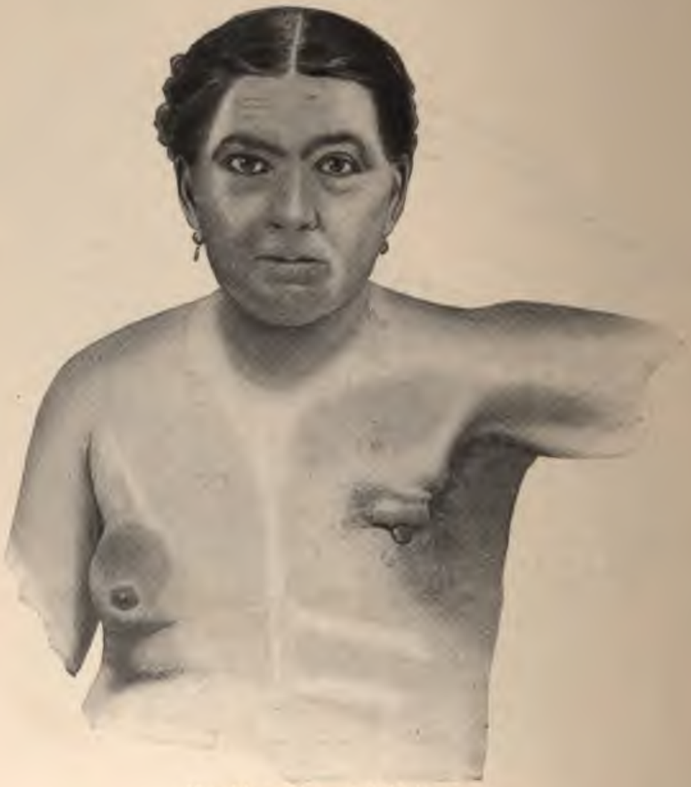


Diagram of clavicle divided, arm abducted: *I*, anterior thoracic glands; *II*, inferior thoracic glands; *III*, posterior or subscapular glands; *IV*, superior or brachial glands; *V*, intermediate glands; *VI*, subpectoral and subclavicular glands; *V.S.* subclavian vein; *A.S.* subclavian artery; *PL.B.* brachial plexus. (Oelsner.)

involved. The bones of the head and the vertebral column may also present secondary foci of disease.

Symptoms.—Cancer of the breast rarely comes under observation or is treated by a physician in its early stages, because at this time there is usually no pain. In exceptional cases the growth may exist for a considerable time without producing any pain whatever. A lump is accidentally discovered in the breast by the woman and causes her to consult a physician. In the majority of cases, however, symptoms develop which attract the attention of the women to the disease. They may be lancinating, shooting pains, or stitch in the side which may extend to the shoulder and upper arm. A dark-yellow or brownish secretion sometimes appears at the nipple, but is of no diagnostic import in carcinoma, because a like fluid has been noted in connection with benign tumors. On palpation a nodule of varying consistence will be found the surface of which is irregular. No matter how large or how small this nodule, it cannot be moved about in the gland. This peculiarity is of distinct diagnostic import and is much in favor of a malignant growth.

FIG. 220.



Atrophic carcinoma of the breast.

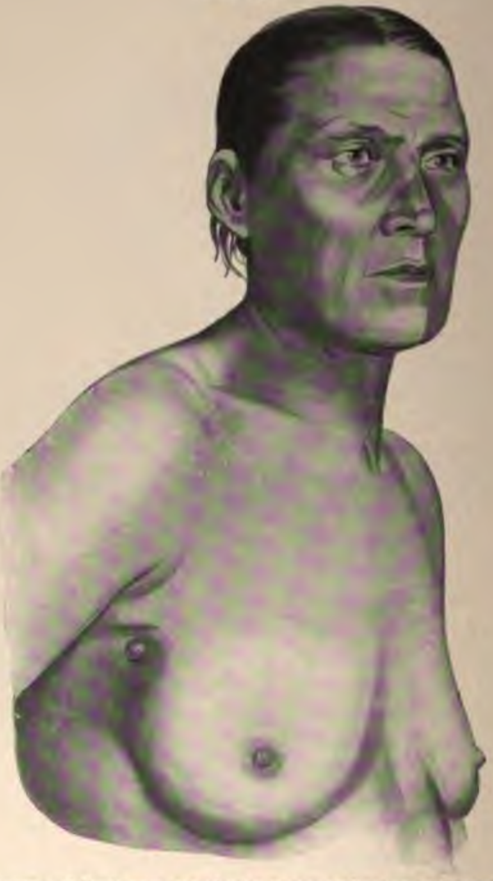
The cancer increases progressively, and the rapidity of growth depends upon its histological peculiarity. Alveolar carcinomata develop rapidly, whereas scirrhus develop more slowly. All carcinomata are characterized by infiltration of the neighboring tissue. The disease extends to the skin, which becomes adherent to the nodules and is no longer movable. This is a very important symptom, and appears as a rule within eight to fourteen months after the appearance of the tumor. Later, ulceration takes place. The neoplasm infiltrates the deeper-seated tissue and involves the muscles of the chest as well as the ribs. It is easy to determine whether the pectoral fascia and pectoral muscles have become involved by abducting the arm at right angles so as to put the pectoral muscles under tension. If the gland has become adherent to the muscles, it will be impossible to move the breast in the direction of the muscle-fibres. When the pectoral muscles are not under tension and the arm is at the side, the tumor moves with the relaxed muscles. When the ribs or the perichondrium is involved, the tumor will be immobile no matter what the position of the arm.

Retraction of the nipple is another important symptom, although it is not necessarily pathognomonic of carcinoma, because the same sign may be present in any process associated with contraction. In atrophic carcinoma this symptom will be present early. As soon as the carcinomatous infiltration reaches the subareolar lymph-vessels the nipple becomes retracted and the papilla immovable. It is not uncommon to see the nipple retracted after interstitial mastitis when abscesses have been opened and have healed. Retraction of the nipple is a suggestive symptom, but the absence of this sign does not necessarily exclude carcinoma.

As a rule, enlargement of the lymph-glands in the vicinity does not take place until late—*i. e.*, until after the tumor has existed for twelve to eighteen months. This is statistically a fact. It is understood, of course, that the enlargement cannot be detected clinically. Of the many hundred cancers of the breast operated upon in the author's clinic in various stages of development, only a very small percentage did not show enlargement of the glands on operation. The enlargement may be so slight that it is impossible to detect clinically, and even considerable enlargement of the glands may escape notice. The arm should be placed close to the chest for the purpose of examining the axilla, so as to relax the pectoral muscles. One should examine carefully along the lower margin of the pectoralis major and high up in the axilla. The enlarged glands are firm and not sensitive to pressure. One should always examine the armpit on the corresponding side. If the patient has pain in the arm, it is fair to presume that the glands are involved, because this symptom is produced by pressure upon the brachial plexus. The gland first to become enlarged is always the one situated along the lower margin of the pectoral muscle at about the level of the third rib. Sometimes it may be possible to detect a chain of glands leading high up into the armpit, resembling a rosary. In the later stages the cervical and clavicular glands become involved. Enlargement of the gland appears early in one case, late in another. This depends largely upon the rapidity of growth.

As a rule only one nodule is to be felt in the breast, although at times several masses can be made out. Multiple carcinomatous nodules render the prognosis more unfavorable. The outlook is equally bad in cases that show involvement of both mammary glands. Of 924 cases, 62—*i. e.*, 6.71 per cent.—showed evidence of disease in both breasts. The left breast seems to be somewhat more frequently diseased than the right. The difference, however, is so slight that it is of no diagnostic significance. The seat of the carcinomatous nodule is usually in the upper and outer quadrant, for 58 per cent. of the author's cases were in this region, whereas the inner and lower quadrant was involved in only 18 per cent. The remaining cases were near the centre of the

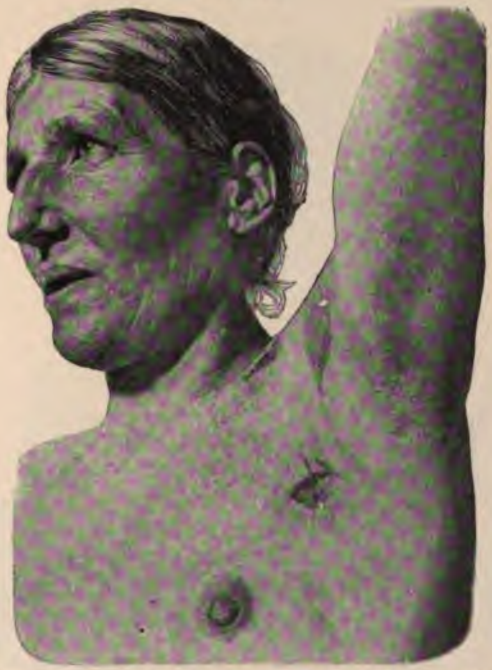
FIG. 221.



Carcinoma of the breast, starting in upper and outer prolongation.

gland. The author has repeatedly observed that a correct diagnosis was not made in cases of carcinoma developing in the upper and outer prolongation of the mammary gland. (Figs. 221 and 222.) It has already been mentioned that this portion of the gland may not seem to have any connection with the rest of the gland. When the condition is discovered on operation, the entire breast, of course, should be removed.

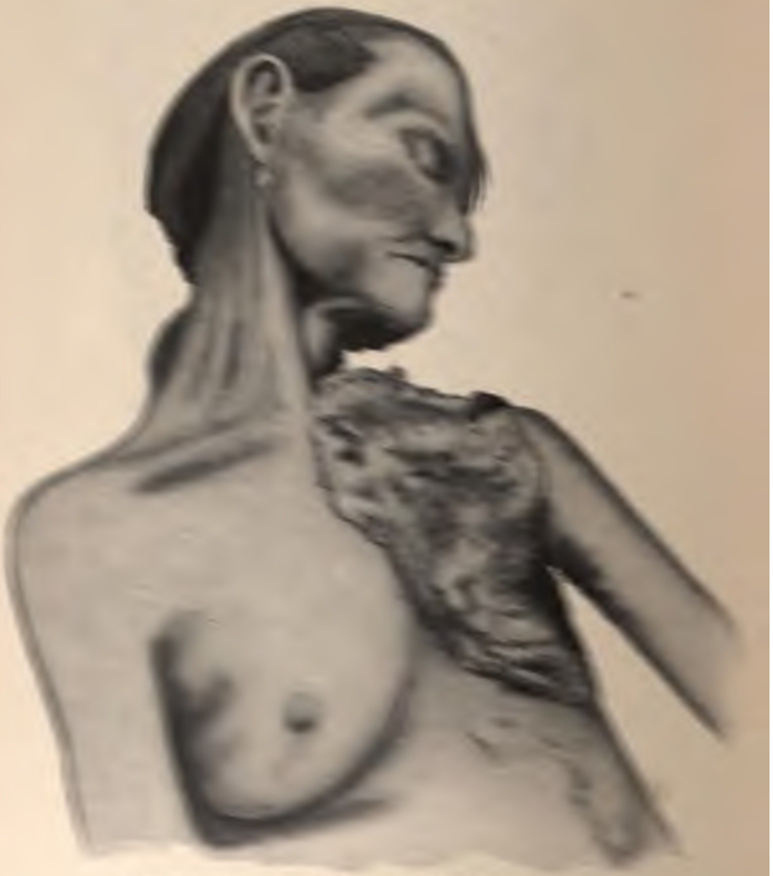
FIG. 222.



Atrophic carcinoma starting in upper and outer prolongation.

Diagnosis.—The first question to decide in all tumors of the breast is whether they are benign or malignant. Statistics show that a tumor appearing in a woman over forty years of age is always suspicious. If there are nodules that are immovable in the gland itself, if the overlying skin be adherent, and if there are lancinating pains, retracted nipple, and enlargement of the glands, there should be no doubt whatever regarding the diagnosis. With small tumors it may be impossible to determine their nature, and the surgeon is sometimes forced to be satisfied with a provisional diagnosis. The nodules may be mistaken for fibro-adenoma, cysts, or interstitial mastitis. Carcinoma is associated with a series of characteristic symptoms, any one of which is sufficient to attract attention, although the surgeon should be careful not to undervalue the importance of any one sign. The malignant nature of the tumor should be detected early from the local conditions, and not when there is cachexia or after the carcinoma has ruptured through the skin. Certain women become anæmic quit early. They are pale, yellow, sallow, and become emaciated eve when the tumor is comparatively small. The author has repeatedl observed women who had pronounced cachexia with only a smal nodule in the breast and only slight involvement of the axillar glands. On operation the metastases were usually found to be muc more numerous than was supposed, and the result of the operation wa

FIG. 228.

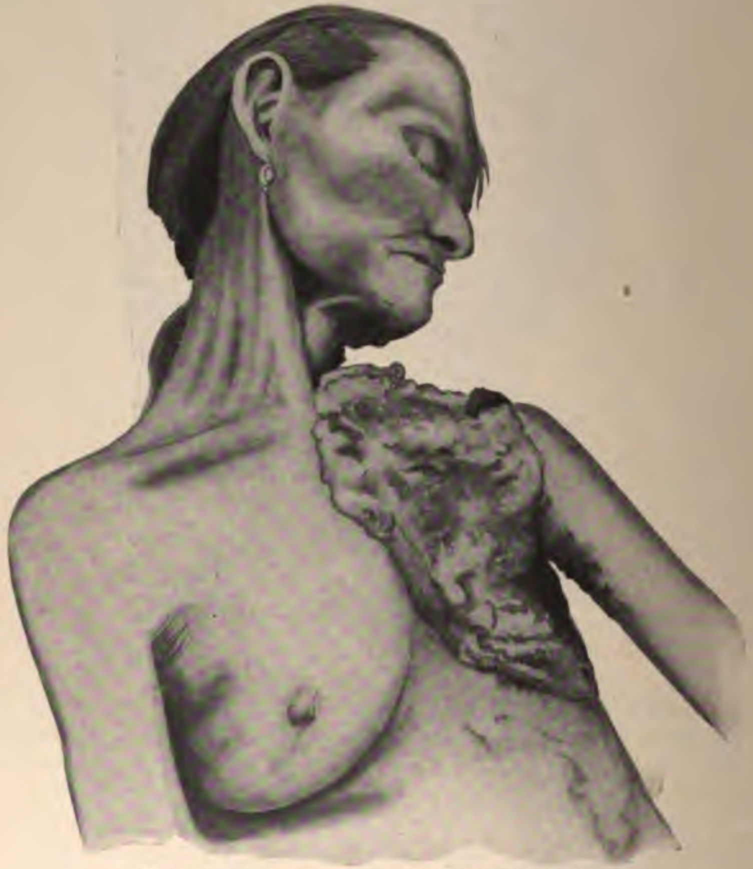


Ulcerating carcinoma of breast with skin metastasis.

unsatisfactory because of early recurrence and metastases in all of th cases. If there is doubt whether the tumor is carcinomatous or sar comatous, glandular involvement will be in favor of carcinoma. In very obese women it may be almost impossible to detect these glands.

Course.—All carcinomata undergo degeneration sooner or late Fatty degeneration of the stroma and epithelial cells is present at a early stage in the softer varieties. The [illegible] and finally ruptured through the skin. Certain women become anæmic quite early. They are pale, yellow, sallow, and become emaciated even when the tumor is comparatively small. The author has repeatedly observed women who had pronounced cachexia with only a small nodule in the breast and only slight involvement of the axillary glands. On operation the metastases were usually found to be much more numerous than was supposed, and the result of the operation was unsatisfactory because of early recurrences and metastases in all of the cases. If there is doubt whether the tumor is carcinomatous or sarcomatous, glandular involvement will be in favor of carcinoma. In very obese women it may be almost impossible to detect these glands.

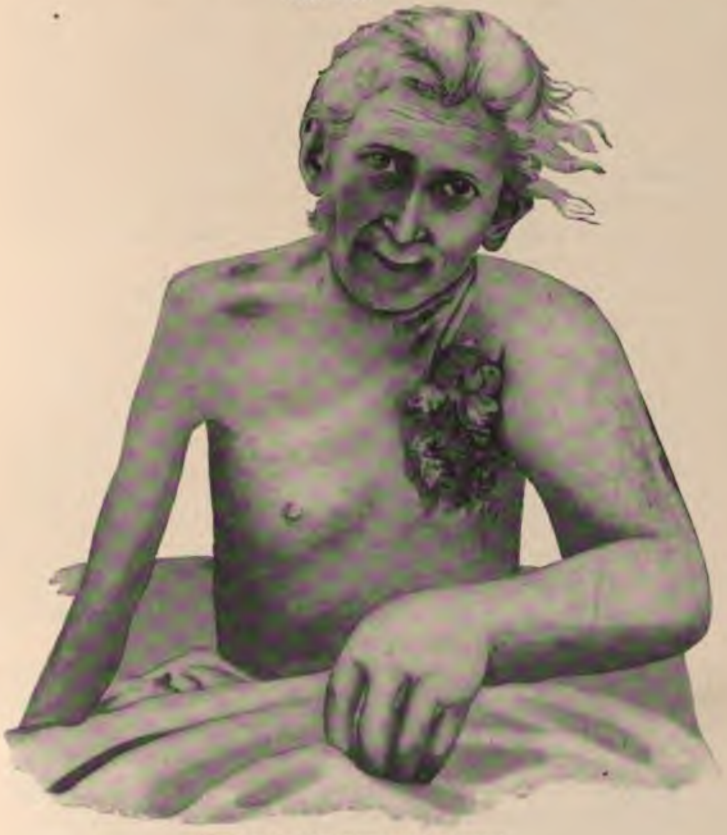
FIG. 223.



Ulcerating carcinoma of breast with skin metastasia.

Course.—All carcinomata undergo degeneration sooner or later. Fatty degeneration of the stroma and epithelial cells is present at an early stage in the softer varieties. The nodules break down and finally rupture externally. An open ulcer with a crater-like opening and indurated edges develops. In cancers with few cells the degenerative changes are followed by contraction and atrophy of the gland. (Fig. 223.) Carcinomatous infiltration extends more and more, sometimes in continuity, sometimes disconnected, so that apparently healthy tissue is found between the nodes. These nodules, however, eventually become confluent. At times it may be possible to trace the extension through the skin. A few scattered nodules appear in the infiltrated skin; the number increases; the skin becomes tense, inflamed, and immovable; and when a woman lives long enough the entire skin of the chest and back is transformed into a board-like nodular cuirasse. Pregnancy has a very unfavorable influence on carcinoma of the breast. The prognosis is always more unfavorable in youthful individuals, and during pregnancy the growth develops rapidly, oftentimes with signs of inflammation. R. v. Volkmann has applied the name mastitis carcinomatosa to this clinical picture. Extensive involvement of

FIG. 224.



Inoperable carcinoma of the breast.

glands may produce severe disturbances of the circulation, especially in the arm, which may become very œdematous (Fig. 224) on account of the pressure.

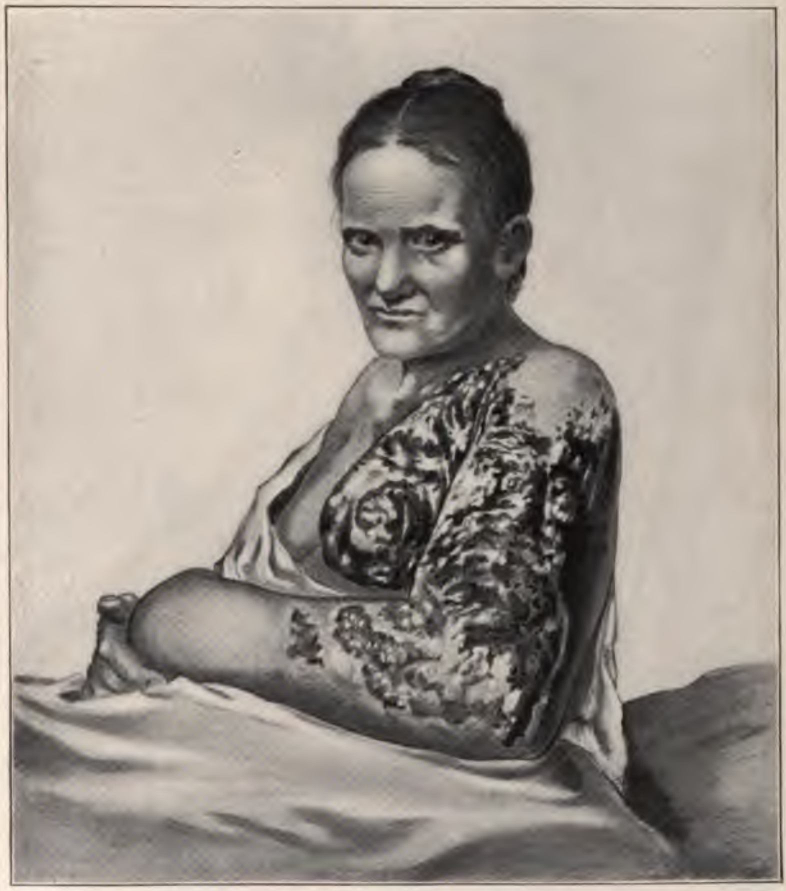
Treatment.—It is very important to attack carcinoma of the breast early, and the author considers that an operation is indicated even in cases that are clinically doubtful. Surgeons are aware that the prognosis depends upon the extent of the growth, and should expose all tumors for the purpose of diagnosis when carcinoma cannot be absolutely excluded. Frozen sections can be made rapidly, and in doubtful cases one should proceed just as if dealing with a carcinoma. An error in this direction is far less deleterious to the patient than assuming a malignant tumor to be benign. The surgeon should no more hesitate to make an exploratory incision to determine the nature of a tumor of the breast than in the case of obscure abdominal tumors. The author considers it inexcusable to keep a woman with a tumor of the breast that cannot be shown to be benign, under observation for months, make use of ointments, and finally be obliged to confess that the condition is carcinomatous. The most favorable time for operation has passed and the chances of recovery diminished.

Operation upon the breast for cancer and cleaning out the axilla is not an especially dangerous procedure. The death-rate is about 5 to 7 per cent. Sepsis, heart-failure, emboli, and hypostatic pneumonia are the chief causes of a fatal termination. Of 189 women operated upon in the author's clinic for cancer of the breast, 5 died within the first four weeks after operation—*i. e.*, 2.6 per cent. In Bergmann's clinic the mortality is 3.1 per cent. and in Czerny's 1.3 per cent. The average prolongation of life of women with cancer of the breast, according to Winiwarter, Oldekop, and Horner, is without operation twenty-seven to thirty-two months; with operation, thirty-seven to forty months.

The number of permanent cures seems to increase from year to year, owing to improved methods of operation. Recent statistics show permanent cures over three years in 42 per cent. of the cases (Rotter, Heidenhain); Mahler, 21 per cent.; Guleke, 29.79 per cent.; Gebele, 16.9 per cent.; and Horner, 19.4 per cent. The results of operation will depend upon whether the patient presented herself at the time when the glands were not involved, or at least only slightly so. When this is not the case, even the most radical operation does not seem to be effective. The operative technic has improved considerably during the last ten years, which explains the infrequent local reappearance of the growth. In Volkmann's time, 66 per cent. of the cases had local recurrences, whereas at the present date only about 31 per cent. show local signs of the disease at a later date.

The author believes that cancer of the breast in its early stages is a local disease, and that a permanent cure is possible by radical removal of the tumor. The condition never gets well of itself, and the value of other methods of treatment is extremely doubtful. A permanent cure can only follow operative interference. He considers that an

PLATE XXII.



Neglected Carcinoma of Breast. (Brewer.)

operation is counterindicated in cases in which there is extensive involvement of the skin or of the ribs, and when there are immovable masses of glands in the axilla associated with neuralgia and disturbances of circulation. It is evident that no operation is possible when internal metastases exist or when the women are cachectic and exhausted. Enlargement of the clavicular and cervical glands should not deter surgeons from operating. These may be removed by extensive dissection. The author's experience has led him to exclude from operation cases of carcinoma with extensive glandular involvement, because the results are unfavorable.

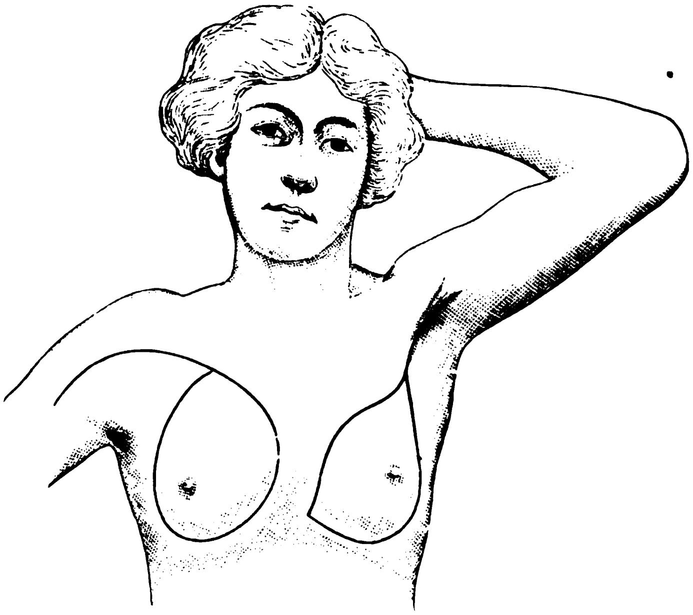
Atrophic cancers are also exempt from operation, because this type of cancer in senile individuals grows extremely slowly and may exist for years. Suppuration of the cancer is in itself a counterindication for operation. Surgical interference is indicated in all cases in which there is a possibility of removing all the diseased tissue and when the general condition warrants interference.

The preparation for operation is that generally recommended. The patient should have a warm soap bath the day before operation. The hair should be removed from the armpit and the region washed with tincture of green soap, carbolic acid, lysol, or some other antiseptic solution, followed with ether or alcohol. A moist poultice of 5 per cent. boric acid or weak carbolic acid or corrosive sublimate is applied to the chest, back, and upper arm. Immediately before the operation the field is again washed with ether and the arm of the side affected covered with a sterile bandage. A sterile cap covering the hair is placed over the head. Sterile sheets should cover the entire patient except the field of operation. The position of the patient should be horizontal on the back with a small pillow under the head. The arm on the diseased side should be abducted at right angles. When ulcers are present, they should be washed with strong antiseptic solutions, such as a 20 per cent. solution of zinc chloride, and dusted with iodoform or painted with tincture of iodine and protected with cotton tampons or cauterized.

The author considers it absolutely necessary to remove the entire breast and at least the superficial fibres of the pectoral muscles in any cancer of the breast no matter how small the tumor. He also believes that the axilla should be dissected even when no glands can be felt. According to Heimann, 2073 women were operated upon in 1895 and 1896 for cancer of the breast, and in only 287 was the axilla cleaned out.

The skin-incision (Fig. 224) is elliptical around the breast, meeting at the anterior margin of the axilla and then carried through the armpit. The nipple should always be removed. Considering the intimate connection between the skin and the mammary gland, especially in thin women, one should be extremely careful about dissecting back the skin, and be sure not to leave any small bits of gland which may reach up to the corium. It is safest not only to remove the skin immediately over the cancer, but also to sacrifice the skin over the entire gland. In spite of the large deficiency the area can usually be closed in, although plastic incisions or Thiersch grafts may be necessary. If the cancer is already adherent to the skin, it may be necessary to remove a very extensive portion of the latter. The chance of healing by first intention is of no importance as compared with the danger of recurrence, and any loss of substance can be covered in partially or completely by sliding the healthy breast, as done by Assaky, Franke, Legneu. The skin is separated from the gland along the lower incision down to the pectoral fascia. The vessel should be tied between ligatures before dividing. This step is repeated along the upper margin of the gland. The pectoral fascia is now divided throughout the entire length of incision and the pectoral muscles divided along the sternum and removed with the gland. The clavicular portion of the pectoral may be preserved unless there are cancerous nodules in this region. According to Heidenhain, the clavicular and sternal portions of the pectoral muscle are really separate muscles with individual blood-supply and lymphatic systems. It is not rare to have the clavicular portion uninvolved when the sternal portion is carcinomatous.

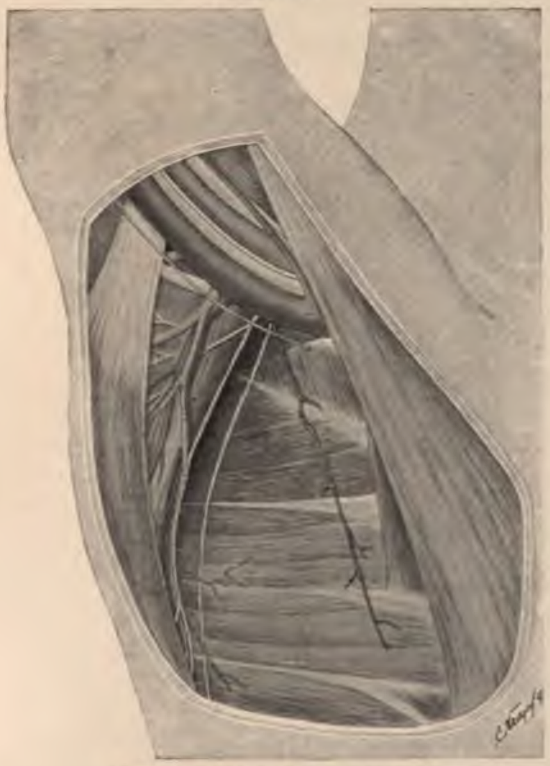
FIG. 225.



Incision for operating on carcinoma of the breast.

One should inspect the glands, especially those along the lower margin of the pectoral muscle toward the axilla. The muscle may be divided with the connective tissue and fat this side of the axilla, although it is better to remove the axillary fat with the breast in one piece. An incision is made from the point where the two cuts around the breast reach the anterior margin of the axilla, across the armpit to the margin of the latissimus dorsi. The skin is reflected upward and downward until the margins of the pectoral muscle and latissimus dorsi are exposed. The axillary fascia is divided along the margin of the muscles and the connective tissue and fat between these muscles is removed. The author prefers to expose the axillary vein in the upper arm and clean the vessel with forceps or scissors. This will guard against accidental injury later. The connective tissue extending over the coracoid process is removed at the same time, while the pectoralis minor is held upward with a blunt retractor. It is best to relax this muscle a little by bringing the arm nearer the side. The subscapular nerves, especially the second and third, should be preserved if possible so as to avoid partial paralysis of the shoulder. It is not very difficult to remove the axillary fascia and all the fat and connective tissue of the armpit from beneath the pectoralis minor and on the serratus. (Fig. 225.) The vessels should always be tied before dividing, which will limit the hemorrhage to a minimum. Lymph-

FIG. 226.



Topography of the axilla. (Rückert.)

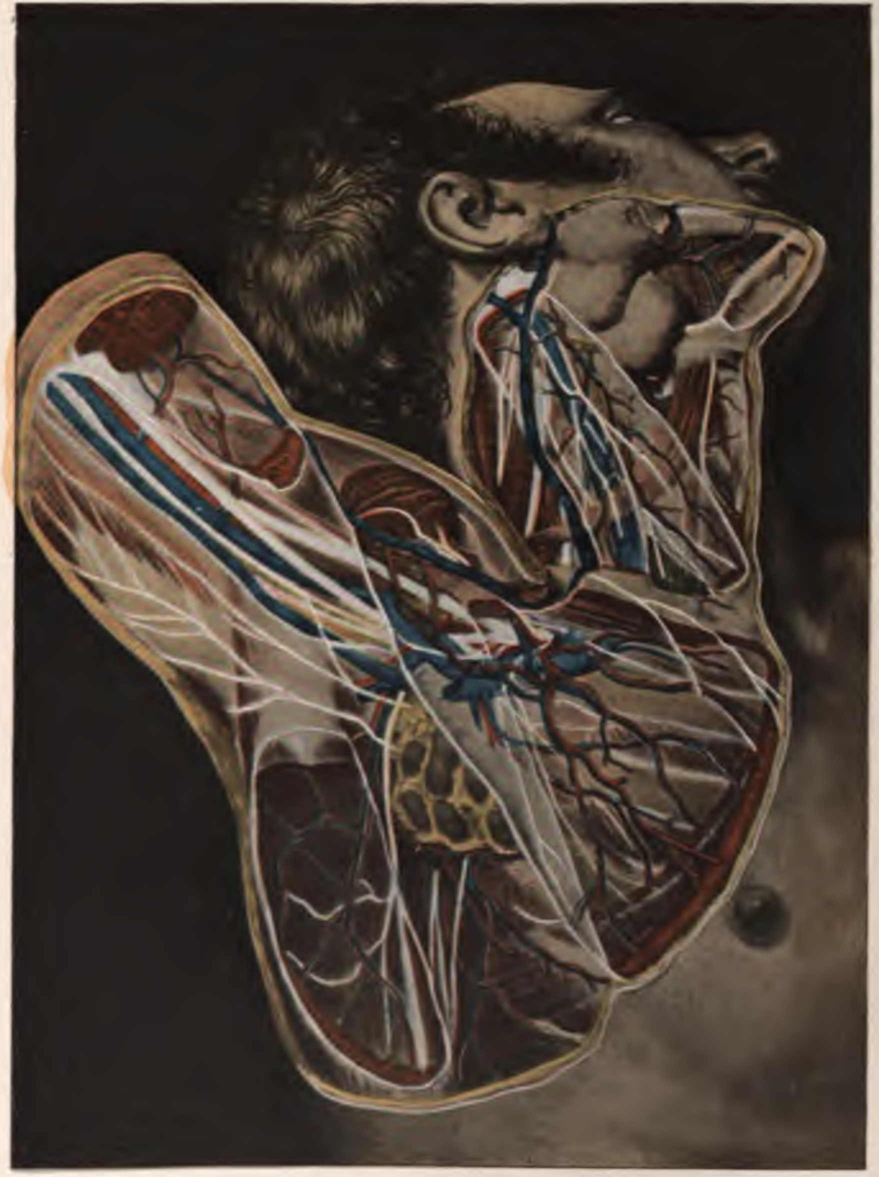
glands that can be felt high up should not be dug out with the finger and pulled up, because this does not guarantee that all the infected lymph-channels will be removed, and besides, the torn vascular twigs often give rise to annoying hemorrhage. When the glands are adherent to the axillary vein, it is more difficult to remove them. They should be separated by blunt dissection if possible, and when this cannot be done the vein should be resected. No serious disturbance of circulation follows this step, although at times extensive œdema of the arm may develop on account of the associated removal of lymphatic vessels. When the vein is torn longitudinally, an attempt should be made to close the tear with sutures. The author has done this repeatedly with success, and considers the procedure more reliable than lateral ligation of the wall. When the clavicular glands are found involved, one should divide the pectoralis minor, which will afford better access to this region. If it is necessary to remove the supraclavicular gland, an incision should be made similar to that for ligation of the subclavian artery, or the wound may be enlarged by an incision carried over the clavicle, which is temporarily divided. Sufficient room is obtained in this way to remove the enlarged glands without damaging the nerves. It seems to the author doubtful whether the success in operations of this sort is proportionate to the severity of the interference, because in these cases the intrathoracic lymphatics are almost certain to be diseased. Heidenhain's and Stiles' investigations have shown how very much more extensive lymphatic infection may be than the evident metastases would seem to indicate. In carcinoma with involvement of the clavicular gland therefore the operation in all probability will be done too late, and a permanent cure extremely doubtful.

Some surgeons commence the operation by dissecting the axilla. It is best to remove the breast and the fat in the axilla in one piece so as to guard against infection from inoculation. Other surgeons operate by removing the breast and axillary fat from above downward, and divide the whole mass along the margin of the latissimus dorsi.

After stopping the hemorrhage, the wound is washed with sterile salt solution and the axilla drained. An incision is made along the margin of the latissimus dorsi sufficient to admit a short, thick drainage-tube. The wound above is then closed with interrupted or continuous sutures. Sometimes a second or third drain is placed for safety' sake in the middle of the wound. The bandage applied should cover the chest, back, and neck of the patient, and should be adjusted while the patient is in a horizontal position and pulled over the end of the table. A small amount of fluffed gauze is placed in the axilla so as to press the skin against the underlying chest-wall. The dressing itself should be large, and can be left in place for several days. The author prefers to do the first dressing on the eighth day in favorable cases without pain or temperature. The drains and the majority of the sutures are removed and a smaller dressing applied.

The author has repeatedly noted abundant secretion of a serous

PLATE XXIII.

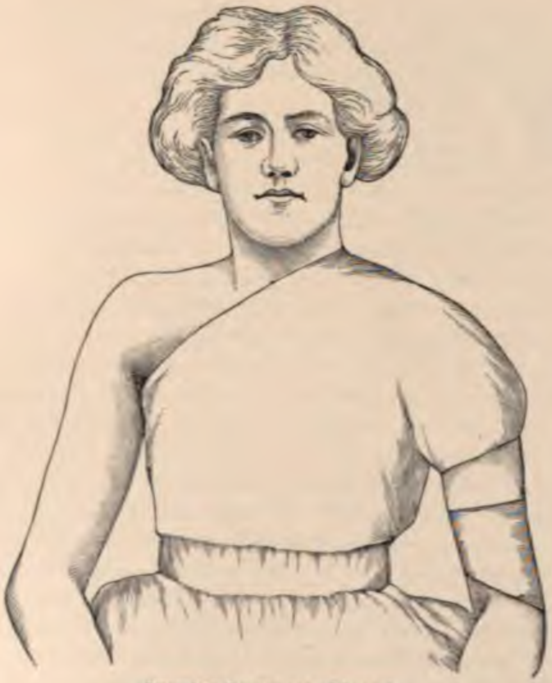


Anatomy of the Axilla.

fluid which might almost be considered to be lymphorrhœa. This renders frequent changing of the dressing necessary. Tillmann recommends arsenic in the after-treatment for the purpose of preventing recurrence.

The investigations of the above-mentioned authors have shown that secondary invasion of retromammary and perimammary fat may take place comparatively early, and that metastases may develop not only in the axillary glands, but also in the pectoral lymphatics. These facts are responsible for the more radical methods of operating in vogue at the present time. One is no longer satisfied with cleaning the axilla and removing the pectoral fascia. The pectoral muscles themselves, and even the latissimus dorsi and the serratus, have been removed, and the clavicle is divided for the purpose of gaining access to the clavicular glands. The skin covering in the breast is removed over an extensive area and the defect closed by a plastic operation.

FIG. 227.



Dressing for cancer of breast.

Modern investigations have only proved that the cancer-cells are distributed from the mammary gland at a period much earlier than was supposed, and that the former methods of operating could not possibly remove all metastases. The future will decide whether the more radical modern operations will increase the percentage of permanent cures. At the present time the information as to the fate of the patients operated upon in this way is so slight that the objections to this radical method of proceeding cannot be totally disregarded. As a matter of fact, the operations are much more difficult, the loss of blood is greater, and the danger to the patient much more severe.

Joerss, in Greifswald, reports 35 radical operations: 10 of these (28.5 per cent.) were well and free from recurrences after three years; 14 (40 per cent.) have local recurrences; and 9 (25.7 per cent.) died of internal metastases; 2 died of intercurrent diseases. Butlin reported 13 cases operated upon by Halsted's method, 9 of which were free from recurrence after three years. Rotter reports 36 per cent. of permanent cures—*i. e.*, patients free from recurrence after more than three years.

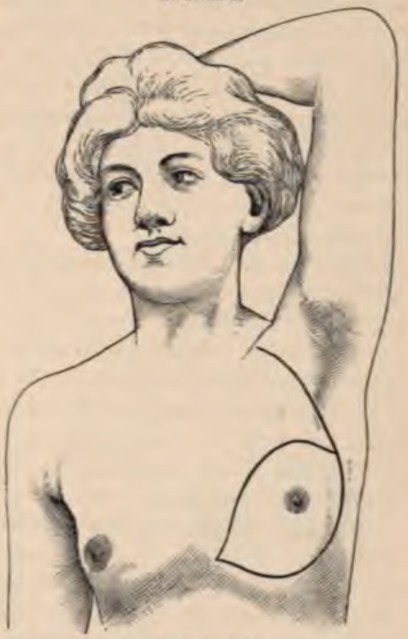
Kocher's report of 8 cases in which the cancerous nodules of the breast were only partially removed, shows how careful one should be in judging of the value of these statistics; 6 of these showed no signs of recurrence after three years.

The success of operation depends upon the extent of the disease. The author confines himself to cleaning carefully the axilla and removal of the sternal portion of the pectoral muscles. This does not materially complicate the operation. The functional disturbance following removal of the pectoral muscles is comparatively slight. Halsted, W. Meyer, Pansini, Rotter, Heidenhain, Helferich, and others, are most radical, and remove the skin overlying the breast, the entire gland, the surrounding fat as far up as the clavicle, and in the median line as far as the sternum, downward as far as the abdominal muscles, and to the side of the latissimus dorsi. The axilla is dissected at the same time. The pectoral muscles are moved and the clavicle is divided. The steps of the operation are as follows: Two curved incisions are made around the breast, and from the point of junction an incision is carried along the margin of the axilla to the insertion of the pectoralis major. A vertical incision is carried upward from this first incision at about the point of junction of the middle and outer curve of the clavicle. The three skin-flaps are now dissected up, the upper one as far as the cephalic vein and collar bone, outward as far as the insertion of the pectoral muscle to the humerus, inward to the sternum, and downward to the latissimus dorsi. The insertion of the pectoral muscle to the tumors is divided and the muscle dissected off back to the clavicular insertion. The pectoralis minor is divided close to the coracoid process. The large vessels are exposed and the diseased glands removed. The vessels going toward the chest (superior thoracic, acromiothoracic, long thoracic) are divided between ligatures. The axillary fat is removed from above downward and from the latissimus dorsi upward. The fascia of the subscapularis and latissimus dorsi is removed at the same time, as well as the fascia on the anterior surface of the serratus, forward to the insertion of the pectoral muscles. These are divided along the ribs over the intercostal muscles, and along the clavicle. The hemorrhage from the anterior perforating branches of the intercostal and internal mammary is not profuse. The clavicle is exposed and divided for the purpose of removing the clavicular glands.

Kocher makes two incisions around the breast, the lower one of which is continued along the posterior margin of the axilla and then forward across the insertion of the pectoral muscle to the clavicle. Stiles recommends the following procedure for the purpose of determining whether all carcinomatous tissue has been removed. The excised breast is cleaned and all blood removed, and then placed for ten minutes in a 5 per cent. solution of nitric acid. It is then rinsed in running water. The fat will appear yellow, the connective tissue homogeneous and somewhat gelatinous, and the gland-tissue and cancerous area opaque and dark grayish-white. In this way it can be determined whether portions of the gland or foci of cancerous tissue have been divided and a portion left behind.

The medicinal treatment of cancer of the breast is to be condemned, because there is no proof that the disease has ever been healed by internal medication. The results of electrolysis are also negative, although Althaus (1878) claims to have seen a cancerous nodule soften and disappear under this treatment. Caustics are painful and unreliable, and it would be only an accident should all of the diseased tissue be destroyed.

FIG. 228.



Kocher's incision.

Thiersch injected a 1 : 2000 solution of silver nitrate into a cancerous breast, and believed that a certain amount of improvement followed. The expectations placed on treatment that attacked the cancer itself to destroy it have not been fulfilled. Many different drugs have been tried in this connection: arsenic, pyoctanin, turpentine, acetic acid, iodine, alcohol, osmic acid, and many others, none of which has any specific action.

The treatment of inoperable carcinoma is symptomatic. The chief duty of the surgeon is to relieve the pain, prevent suppuration, and maintain the patient's strength as much as possible. Morphine may be given when indicated. The author has repeatedly made incisions around an inoperable cancer of the breast with the cautery, as recommended by Nussbaum, and has observed favorable results. The hemorrhage became less, the amount of secretion diminished, and the tumor itself became smaller. Improvement has sometimes followed the use of a 20 to 50 per cent. solution of zinc chloride, and excochleation of a cancerous ulcer with subsequent cauterization may be beneficial. Poultices of 10 to 30 per cent. formalin, and antiseptic powders, such as salicylic acid, iodoform, or bismuth, will tend to limit suppuration in ulcerating breasts. Transplanting of skin over carcinoma as recommended by Kraske is also beneficial at times. The patients prefer as a rule cold antiseptic dressings, such as solutions of lead acetate and carbolic acid. A change in climate will often improve the patient's condition, and a nitrogenous diet is said to be of value, although the author has never become convinced of this statement. Inoculation with erysipelas cocci for the purpose of removing the carcinoma is too dangerous and unreliable. The cancer serum (erysipelas serum) of Emmerich and Schol is absolutely inefficient, as shown by experiments in the author's clinic. Coley's experiments with streptococcic toxin and *Bacillus prodigiosus* have proved of doubtful value, and apply only to sarcoma. Whether Adamkiewicz has been able to cure this condition by injections of cancroin remains for further investigations to prove.

Beatson in 1896 recommended removal of the ovaries in women with cancer of the breast, and Boyd reports 17 cases in which the result was favorable—*i. e.*, the growth of the carcinoma was checked. In 34 cases the result was doubtful or negative. Women operated upon before the menopause are theoretically affected more favorably. Hermann considers that removal of the ovaries is justifiable, and combines this step with administration of thyroid extract.

Œdema of the arm should be treated with tight bandaging, suspension, and massage.

Tumors of the Male Breast.—B. Schuchardt found that only about 1 per cent. of all tumors of the breast affected the male organ, and that of these only about 2 per cent. were cancerous. Although these neoplasms are rare, all varieties of new growths have been observed, such as adenoma, enchondroma, calcareous deposits, fibroma, myoma, cysts, tuberculous and syphilitic tumors, and carcinoma.

Carcinoma is most frequent between the fortieth and sixtieth year (55 of 60 cases), and is hereditary in about 24 per cent. of the cases. Clinically, cancer of the breast develops in men just as in women: a small nodule, diffuse infiltration of the gland, lancinating pain, and sometimes secretion from the nipple. The cause is supposed to be pressure from the suspender-buckle. The course is the same as in women, as is also the treatment.

INJURIES AND DISEASES OF THE SPINAL CORD AND VERTEBRAL COLUMN.

BY PROF. DR. A. HENLE.

INJURIES AND DISEASES OF THE SPINAL CORD AND ITS MEMBRANES.

Preliminary Remarks.—The surgical conditions of the spinal cord are almost all total or partial solution of continuity, generally localized to a few segments. There may be complete solution of continuity produced by crushes, stabs, or gunshot-wounds.

In contusions the nerve-elements usually suffer most, whereas the shape of the cord is preserved by the surrounding bony tissues and membranes.

In cases of compression the function of the nerve-structures is temporarily destroyed without affecting the contour of the nerve-tissue. When these injuries involve a complete transverse section, transmission of impulses from and to distant regions of the body is interrupted. Not only this, but the function of the spinal cord itself is interfered with, such as nutrition, reflex action, etc., in the region corresponding to the injured tissue. This latter form of disturbance is the less severe and may disappear after a comparatively short time. In other cases signs of degeneration may appear soon. When the nerve-elements are destroyed, the interrupted nerve-tracts in the spinal cord never reunite. The contour may be restored, but the damage is repaired by a scar composed of neuroglia devoid of function.

Fickler has recently expressed the opinion that a certain amount of regeneration of nerve-fibres might take place provided the blood-supply was not destroyed, and that new sheaths are supposed to develop around any axis-cylinders that may have been preserved.

Contusion of the spinal cord is secondary to some temporary or permanent damage to the vertebral canal which squeezes the cord at the time of injury. There is usually more or less extensive destruction of the latter. Compression may be produced by any process diminishing the lumen of the bony canal or by any condition affecting the membranes at the expense of the nervous elements.

Paralysis due to compression develops in diseases of the vertebral column, such as caries, carcinoma and other tumors, and those neoplasms developing in the vicinity of the vertebral canal and encroaching upon the column, either through the intervertebral foramina or on account of ulceration of the bodies. Dislocated fragments of a vertebra and masses of callus may also give rise to compression, as do processes developing in the interior of the column, such as hemorrhages, abscesses, tumors, parasites, etc. The lesion may be extradural, intradural, intramedullary, or in the membranes themselves. Not infrequently pressure-paralysis may be due to œdema of the spinal cord. (Kahler, Schmaus.) This type of paralysis may completely resolve even after it has existed for a long time (five or six years, Oppenheim). It may be that the anæmia produced by compression bears some relation to the paralysis. (Ziegler.)

The symptoms produced by compression of the spinal cord are included in the term pressure-myelitis, although pathologically as long as the disturbance is purely functional no inflammation is present. After the nerve-tissue disintegrates reactive processes develop in connection with absorption, and there is present a variety of myelitis.

Clinically, it is impossible to make a differential diagnosis between the varieties of interrupted conduction. When the symptoms show exacerbations and remissions, there may be some slighter type of compression without degeneration, while persistence of the symptoms is in favor of degenerative processes. The length of time that the symptoms have persisted is of no great diagnostic value.

Paralysis due to partial solution of continuity of the spinal cord may completely disappear. This is not because of regeneration of the tracts affected, but because their function has been assumed by the intact portion of the cord. The paralysis following unilateral lesions in the cord disappears as a rule. Experiments have shown that the healthy half of the cord undertakes the duties of the destroyed half. (Turner, Rossolymo, Mott.) Bruns does not believe that this is possible, and holds that in cases in which the function was restored, the corresponding nerve-tracts were only compressed, and that the paralysis produced by destruction of nerve-tracts is always permanent. If the power of conduction is definitely interrupted, secondary degeneration appears; usually in the efferent tracts (pyramidal tracts), away from the lesion (descending degeneration), and in the afferent tracts (Goll, Burdach), or cerebellar tracts and Gowers' tracts, above the lesion (ascending degeneration). The degeneration, especially in surgical cases, will rarely be limited to one of these bundles, and symptoms of pyramidal paralysis, for instance, alone will be found only in exceptional cases. There will be a combination depending, of course, upon the position of the lesion. Practically it is of great importance to distinguish complete from partial interruption. The clinical picture of unilateral paralysis is so characteristic and relatively so common that it will be considered separately.

Complete transverse destruction is in the majority of cases traumatic.

When pressure is brought to bear slowly, the damage is rarely complete, and death usually takes place before the condition progresses thus far. After an injury there will be no trace of conduction either to or from the regions whose nerves have been interrupted. There will be complete anæsthesia; even abnormal sensations are as a rule absent. There is complete paraplegia. The paralyzed muscles may twitch on account of the irritation of the pyramidal tracts. (Bruns.) This is, however, extremely rare. A peculiarity of these paralyses, which cannot even be explained theoretically is that in the vast majority of cases the paralysis is flaccid, with total loss of tendon-reflexes. On the other hand, when the ganglion-cells are not destroyed, there will be no atrophy or reaction of degeneration except that produced by inactivity of the muscles. This observation has been corroborated elsewhere, except in one case of tuberculosis of the vertebral column with paraplegia reported at the clinic in Breslau. During a laminectomy the spinal cord was completely divided, as shown five and a half months later at autopsy. The reflexes were restored twenty-two hours after operation. (Kausch.) It cannot be stated whether the laws governing the absence of tendon-reflex apply where total destruction of the transverse section takes place slowly (tumors). D. Gerhardt's and Senator's cases seem opposed to this view. Other reflexes, especially those of the skin, are much less constant, and are not of so great diagnostic value in cases of total complete interruption. They may also be preserved. The vasomotor nerves are also paralyzed with transverse lesions. The corresponding regions of the body are warmer than normal and the subcutaneous veins are distended. Priapism is due to vasomotor paralysis, and is noted especially in youthful males. The vasomotor paralysis is of importance for the internal organs, because they receive an insufficient supply of blood on account of the increased hyperæmia of the lower extremities. Wagner and Stolper report disturbances of nutrition in the kidneys following this anæmia. The quantity of urine may be considerably below normal and kidney-changes are recognized clinically by the abundance of necrotic epithelium. Kocher describes a similar desquamation of the bladder mucous membrane. This loss of epithelium in the pelvis of the kidneys and bladder bears some relation to the presence of stones, which are not infrequently noted with injuries of the spinal cord. When there is a certain amount of injury of the column itself, the elimination of salts of calcium absorbed at the seat of injury may favor the formation of stones. (Kocher.) Cystitis and pyelonephritis may also be of etiological importance in the formation of stones in the bladder and kidney.

The bladder and rectum in complete lesions are no longer under the power of the will and are completely anæsthetic. Retention of urine is due to reflex contraction of the sphincter of the bladder. The plexus found in the bladder-wall, therefore extramedullary, may produce this condition when the spinal centres have been disturbed. The contractions of the extensor muscles are overcome by the more powerful detrusor muscles. If the bladder is left to itself, the sphincter will become gradually distended and there will be intermittent dribbling of urine. After several days, or perhaps a week, the spasm of the contractor muscles ceases, and the urine is voided unless there is some purely mechanical obstruction. The dorsal position, in which the bladder is lower than the opening of the urethra, is of importance in this connection, as is also the size of the urethra and in males the prostate gland. Urine may be expressed from the paralyzed bladder by simply pressing on the abdominal wall. After a certain time paralysis of the bladder is followed by cystitis, due probably to the unavoidable use of a catheter, and favored by the influence of vasomotor paralysis. Autoinfection through the intestine is also possible. The retention of feces present in the early stages soon gives way to incontinence. In the absence of straining, obstinate constipation develops and it may be necessary to clean out the rectum. The absence of normal defecation is largely due to paralysis of the abdominal muscles. Besides retention of feces due to spasm of the sphincters, there is another variety belonging to the field of paralytic intestinal obstruction, which is not infrequent with partial lesions. This paralysis, which may be partly due to involvement of the splanchnics, can be temporary. The author had occasion to see a patient die with symptoms of intestinal obstruction who had a fracture of the third cervical vertebra and hæmatomyelia. Similar cases have been reported by Stolper and Murphy, in which laparotomy was performed.

Ectasia ventriculi, observed by the author in two patients with paraplegia, may be severe, and the organ may almost reach to the symphysis. In both cases there was distention of the duodenum. In all probability the distention is due to compression of the duodenum by the mesentery of the small intestine. The direct cause of death in both of these cases was the stomach lesion.

Decubitus, after complete transverse lesions, may be severe. Other trophic disturbances, such as the formation of bullæ, are not quite so common.

First will be considered the clinical picture of partial lesions, and of these the unilateral lesions. It is not surprising that in human beings the lesion is not strictly unilateral, on account of the primary cause (injuries, tumors). This explains why the symptoms are not similar in the cases reported. At the level of the lesion the gray and white substance become destroyed, and also a number of the motor ganglia situated in the former. The muscles belonging to these become lax and degenerate. Contrary to these nuclear paralyses, the muscles receiving their nerve-supply from the region of the spinal cord below the lesion show signs of pyramidal paralysis, which is spastic because the reflex arc is preserved. Atrophy due to lack of use appears, but there is no reaction of degeneration. The condition of the skin-reflexes varies. They may be absent, diminished, or increased. The vasomotor nerves are temporarily paralyzed. Priapism is as a rule absent.

Motor paralysis usually begins to disappear within one or two weeks after its onset. In spite of persistent weakness the function of the muscles may be quite good. This event may possibly be brought about by tracts situated in the half of the spinal cord not injured and which serve as a reserve. According to Wernicke and Mann, all of the muscles do not have double innervation; only the extensors of the thigh and knee and the plantar flexors of the foot. These are the only muscles that become practically normal after unilateral lesions, whereas the remaining muscles remain paralyzed. The bladder and rectum seem to have a nerve-supply derived from both sides. They may not be paralyzed at all; and if so, the condition may continue only ten to fourteen days.

Muscular sense is destroyed on the affected side, and when it reappears later than motion a stage of ataxia is first passed through.

A symptom not sufficiently explained is the appearance of hyperæsthesia on the injured side. This applies to touch, pain (hyperalgesia), and temperature (thermohyperæsthesia). Sometimes there are radiating pains and painful paræsthesia. These symptoms may persist for years.

There are always sensory disturbances on the side not injured, which do not consist of anæsthesia, but affect the senses of pain and temperature. The tactile sense is preserved. Analgesia and thermal anæsthesia, which need not necessarily be combined, persist longer than the hyperæsthesia of the other side, and in numerous cases do not improve at all.

In injuries of the upper dorsal segment, and in the region of the neck also, ocular symptoms due to paralysis of the vasomotor constrictor fibres of the sympathetic will be noted.

The partial lesions of the spinal cord depend, of course, on the level of the injury for the symptoms produced. Injury to the pyramidal tracts may interrupt conduction from the cerebrum to all the ganglion-cells of the anterior gray column situated below the lesion. The motor fibres that leave these cells are no longer controlled voluntarily. As long as these ganglion-cells are preserved as trophic centres no degeneration takes place in the corresponding nerves or muscles. The latter may become somewhat atrophied due to lack of use. The nerves and muscles show normal electric reaction, and the reflex arc is not disturbed, and may even be increased on account of the lack of inhibition. The absence of inhibition may be followed by pronounced spastic contractions of the muscles supplied (pyramidal paralysis). Disturbances in the region of the anterior horn interfere with the transmission of impulses from the cerebrum to the periphery and destroy the reflex arc, producing flaccid paralysis. Degeneration of the ganglion-cells is not infrequently associated with fibrillary muscular twitching. The muscle and its peripheral nerve disintegrate on account of destruction of the trophic centre. A reaction of degeneration and finally complete absence of reaction will be noted. If only individual ganglion-cells or groups of cells have been destroyed, the secondary changes will be limited to the corresponding nerves and muscle-fibres. Although destruction of ever so small a portion of the pyramidial tract paralyzes all muscles, the nerves of which leave the spinal cord below the lesion, nuclear paralysis may be quite circumscribed and affect regions high up in the cord while those lower down remain intact. Paralysis of the arms without paralysis of the legs does not occur with incomplete lesions of the pyramidal tract, because experience has shown that the long tracts are first affected. If, therefore, a partial lesion is above the cervical enlargement, the legs will always be more paralyzed than the arms.

Division of the anterior roots has the same effect as destruction of the ganglion-cells. A lesion in the posterior tracts will be followed by disturbances of muscular sense and will produce ataxia. The sense of touch may also be lost. The reflexes will be preserved. All sensory functions are destroyed with the posterior roots, also the reflexes on account of the interrupted reflex arc. Absence of muscular sense is followed by sensory ataxia.

It may be that the posterior root contains some trophic fibres, and that injury to these favors the development of decubitus, etc. The view generally held at present is that these superficial lesions are due to external influences largely, against which the body is no longer able to defend itself on account of the destroyed sensation.

A lesion in the posterior horn, especially near the base and central canal, will produce disturbances of pain-sense and temperature. When the tracts for the different sensations become disconnected in the spinal column, there may be partial sensory paralysis. This is observed almost exclusively in cord lesions, and is of diagnostic importance in this connection, although it has been observed with incomplete division of the roots. A similar relation exists between disturbances in the long sensory tracts of the cord and the posterior roots as between pyramidal paralyses and paralysis of the motor roots or of the ganglion-cells. Destruction of the long tracts means destruction of sensation in all regions supplied by nerves leaving the cord below the lesion. Lesions in the roots may produce circumscribed disturbances that may affect the arms alone, while the legs remain normal.

Besides paralysis, symptoms of irritation may be indicative of some pathological process. There may be tonic or clonic spasms, hyperæsthesia, or paræsthesia. Symptoms of this sort may be secondary to lesions in any portion of the central nervous system. They are relatively infrequent in affections within the cord, but are extremely common when the root is irritated, and are of special differential diagnostic import in connection with sensory irritation. It may happen that after division of the sensory tracts the central end remains irritated. Pain, etc., is referred to the periphery, although the nerves leading to these regions have been divided. Muscular spasm may be associated with pain, and there may be symptoms due to irritation of the motor and sensory regions at the same time. The irritation is probably always of primary sensory origin and the muscles are involved by way of the reflex arc.

If these points are sufficiently borne in mind, it will frequently be possible to locate the level of a partial lesion. Generally speaking, motility is more interfered with than sensation, which does not mean, of course, that sensation might not be disturbed alone. Motion suffers as a rule more frequently and to a greater extent.

In pyramidal paralysis the tendon-reflexes after sudden interruption may be absent even when a portion of the transverse section is preserved. They soon return, are somewhat increased, and remain so longer than the paralysis provided this disappear. The paralysis, of course, is not always complete. With slight damage paresis is produced even without increase of the reflexes or other spastic signs. Other reflexes, especially those of the skin, may be increased, so that even the slightest touch, such as moving the bedclothes, produces active reflex action. There may be flexion of the knee and hip, which when very marked is no longer a sudden twitching, but persists as a cramp lasting for several seconds. Twitchings and spasms may develop spontaneously, due to irritation in the sensory areas of the spine, and may be associated with considerable pain. The spasm sometimes develops spontaneously or is due to reflex action and resembles the trembling of a chill (spinal epilepsy, Brown-Séquard). One should always be careful, especially in hasty examinations, not to consider these movements voluntary, and thereby overlook total motor paraplegia. Later, contractures may develop, especially of the flexors and adductors.

Vasomotor paralysis corresponds generally to the motor paralysis in general, although it may be absent or the vessels may become constricted in the paralyzed region, due to irritation of the vasomotors. Priapism is often absent and the erections due to hyperæsthesia are not infrequently painful.

Sensation may be intact. When there are sensory disturbances, they do not coincide with the motor paralysis, and are often limited to individual sensations, or combined with hyperæsthesia and other symptoms of irritation. The latter not infrequently make their appearance just before the sensory paralysis following prolonged compression, and may reappear after disappearance of the paralysis.

The bladder and rectum may act perfectly normal, even with complete motor paraplegia. Retention of urine has been observed frequently with normal sensation, or there may be even hyperæsthesia of the bladder; then the patient has a desire to pass urine but is unable to do so voluntarily. Intermittent incontinence is also observed. The bladder fills to a certain point and then empties involuntarily.

Besides interruption of the long tracts, especially of the pyramidal tracts, a nuclear paralysis may develop, of course, with any partial lesion of the cord, corresponding to the level of the pathological process.

It is of great importance in surgery of the column and cord to be able to locate the lesion, whether primary or secondary, even in the absence of external changes. Pathological conditions and experiments have shown that the function of the individual segments of the spinal

C. 1	Rectus cap. ant., obliqu. cap. sup.	Rect. cap. lateral. Twig to transversalis.	Rect. cap. post., min. post. cervic.	Longus capitis, sternothyreoideus.		Semispinalis capitis, spinal. cap. (pars. cran.).	Sternohyoideus.	
C. 2	Sternocleidomastoideus.	Obliquus capitis inferior. Interdigitation of longissimus and transversalis.			Longus colli, longus atlantis, splenius capitis et cervicis, trapezius.	Rect. cap. post. maj., thyreohyoideus.	Omohyoideus.	
C. 3		Scalenus medius.				Diaphragma (C 4). Levator scapulæ.	Geniohyoideus.	Reflexes of extensors of upper arm and forearm.
C. 4	Supra- et infraspinatus, scalenus ant.		Deltoideus, supinator longus, biceps.				Coracobrachialis.	
C. 5	Splenius.	Supinator brevis teres minor.		Pectoralis pars clavicularis. Extensors of the hand.			Rhomboidei.	Scapular reflex.
C. 6		Serratus antic. major brachialis internus.		Pronator quadratus et teres. Long extensors of fingers.		Scaleni.	Extensors and flexors of hand (C. 6).	
C. 7		Long extensors and flexors of fingers. Small hand muscles (interossei and lumbricales [?]). Pronators of the hand (latissimus dorsi, pectoralis p. costalis).					Subscapularis, teres major, triceps (C. 7).	Palmar reflex. Slight tap produces closure of fingers.
C. 8	Inteross. et lumbricales (C. 8).		Flexor carpi ulnaris. Long flexors and extensors of the hand.					The fibres for the dilator pupillæ pass to the lateral column in the 8th cervical and 1st dorsal roots.
D. 1			Thumb and hypothenar region. Long flexors of fingers.					
D. 2.	Serrat. post. sup. D. 1–4.	Intercostales ext. et interni D. 2–11.	Infracostales D. 2–4 et D. 7–9	Transversus thoracis D. 3–6.	Obliquus abdominis ext. C. 4–D. 12.			From C. 5–D. 1 tendon reflexes of the corresponding muscles.

D. 12	Serrat. post. infer. D. 9-12.	Levat. cost. breves D. 2-11.	Levat. cost. longi D. 8-10.	Pyramidalis D. 12-L. 1.	Rectus abdominis C. 5-D. 12.	Transversus abdom. C. 7-L. 1.		
L. 1	Ileopsoas, sartorius.	Cremaster.				Obliquus abdominis int. C. 8-L. 1.		
L. 2			Quadriceps femoris.				N. B. The cervical and dorsal nerves also supply the corresponding muscles of the column.	Patellar reflex L. 2-4.
L. 3				Adductors.				
L. 4	Abductors of the hip, especially of the tensor fasciæ, tibialis anticus.				Extensor digitor. commun. et hallicis (L. 5).			Gluteal reflex L. 4 et 5.
L. 5	Plantar flexors of the foot and long flexors of toes.	(Tibialis anticus), dorsal flexors of the foot.	Outward rotators and extensors of the hip. (Inward rotators?)					
S. 1								Plantar reflex.
S. 2		Small muscles of foot. Flexor dig. brevis.						Tendo Achillis. Bladder. Sphincter.
S. 3-5	Muscles of the perineum and striped muscles of the urethra, rectum, and sexual organs.							The anus centre is below the bladder centre.

NOTE.—The muscles with segment in braces are supplied chiefly from their segment, while those where the segment is not in brackets are supplied entirely by the segment in question.

column—*i. e.*, motion, sensation and reflex action—is fairly well known. Bruns' table, as far as motion and reflex action is concerned, is given in such a way that the horizontal lines correspond to the individual segments (see pages 618 and 619).

The table shows that the individual muscles are not necessarily supplied by one segment, and that any muscle receives fibres from the segment above and below, and also from the main nerve. (Sherrington, Bruns.) Sherrington has shown that the sensory areas are not sharply outlined, but overlap each other; although mainly supplied from one segment, they receive sufficient innervation from neighboring segments, so that after destruction of the main root there remains a certain amount of sensation. Bruns believes that this system of communication is much more extensive in human beings than is here indicated. At any rate, it is certain that at least three neighboring roots must be destroyed to render the region supplied by the middle one insensible.

The sensory area of the individual segments is not indicated by the course of the peripheral nerve. This fact is illustrated on the trunk, where the dividing lines are almost horizontal, contrary to the intercostal nerves which follow the curve of the rib. These differences now and again enable a differential diagnosis between peripheral and central lesions. The author wishes to mention in regard to the centrum ciliospinale that the nerves of this region leave the cord with the eighth cervical and first dorsal to join the sympathetic. In the cord itself the centre is supposed to reach from the sixth cervical to the third dorsal; and when irritated, dilatation, paralysis, and contraction of the pupil follow. With paralysis there is retraction of the bulb and the palpebral fissure becomes narrowed. Kocher claims that this centre is in the medulla; that the fibres pass down through the cervical portion of the cord, because these symptoms have been observed in connection with injuries to the uppermost portion of the cervical cord. It is not so easy to determine the level of the lesion as might be expected from the accompanying diagram. Two factors are of importance: interruption of the long tracts and nuclear paralysis. To the latter may be added symptoms due to paralysis or irritation of the roots. The clinical picture of nuclear paralysis is more pronounced the greater the number of cells involved, or, which amounts to the same, the more roots disturbed. This means that the longer the injured portion of the spinal cord, the more pronounced the clinical picture.

It is evident from what has been said regarding the nerve-supply of muscles that several segments must be destroyed to produce complete paralysis with atrophy and reaction of degeneration in a muscle belonging to one segment. These symptoms may be absent for some time, and when present indicate an extensive lesion. If there is nuclear paralysis, it does not mean that it can necessarily be located. It is only possible to detect this condition and distinguish it from pyramidal paralysis when the corresponding muscles are accessible. Isolated sensory paralysis of one segment is usually due to some injury to the root. According to Sherrington's law, paralysis becomes evident only when three neighboring roots are destroyed. The diagnosis is perhaps easier when there are symptoms of irritation, because these may be produced when only one root is affected. The symptoms of irritation may be referable to regions supplied by neighboring segments on account of the communication between the nerves, so that one may erroneously assume the lesion of the cord or root to be more extensive than it really is, whereas in paralysis one is more apt to err in the opposite direction. The signs of sensory irritation are of the greatest diagnostic value because they appear early and are the most constant.

Trophic disturbances may be of value in determining the level of a lesion. It should be remembered that they may have a radicular arrangement just as the sensory disturbances contrary to peripheral neuralgia.

When there is complete interruption of transmission, this may be a valuable aid in determining the seat of the lesion. When incomplete, the long tracts suffer first and the motor tracts before the sensory. The more distal portions will show signs of paralysis first, and when there is any sensory paralysis it is far less marked than the motor disturbances. For this reason the lesion might be supposed to be lower than it really is, according to the symptoms of interruption. This error will be greater if the sensory symptoms are chiefly considered than when the main importance is attached to the motor signs. With complete interruption, which must, of course, be due to a lesion approximately horizontal, all the tracts are interfered with at about the same level, so that the paralysis is more or less symmetrical, and the motor paralysis points to the same segment as the sensory disturbance. Exceptions to this rule occur when there are partial disturbances (œdema and destruction) above the transverse lesion. The paralysis, especially the nuclear paralysis, will then be asymmetrical. With complete interruption the upper end forms the lower margin of the long tract. All centripetal and centrifugal tracts below this lesion are completely interrupted. The upper line of the damage may be diagnosticated in this way, but these symptoms do not throw light on the state of the cord below and in the injured region, and do not indicate the extent of the lesion. In certain cases the extent of the trouble and the condition of the cord below may be indicated by the nuclear paralysis. Where this is present, it must be assumed that the cord has been more or less completely destroyed. If paralysis is absent lower down, any severe injury to the lower section of the cord can be excluded. The nuclear paralysis may enable one to distinguish several different processes. If there is present atrophic paralysis of certain groups of muscles not belonging to neighboring segments, and other muscles supplied by regions of the cord lying between these segments are intact, the presence of several foci may be assumed.

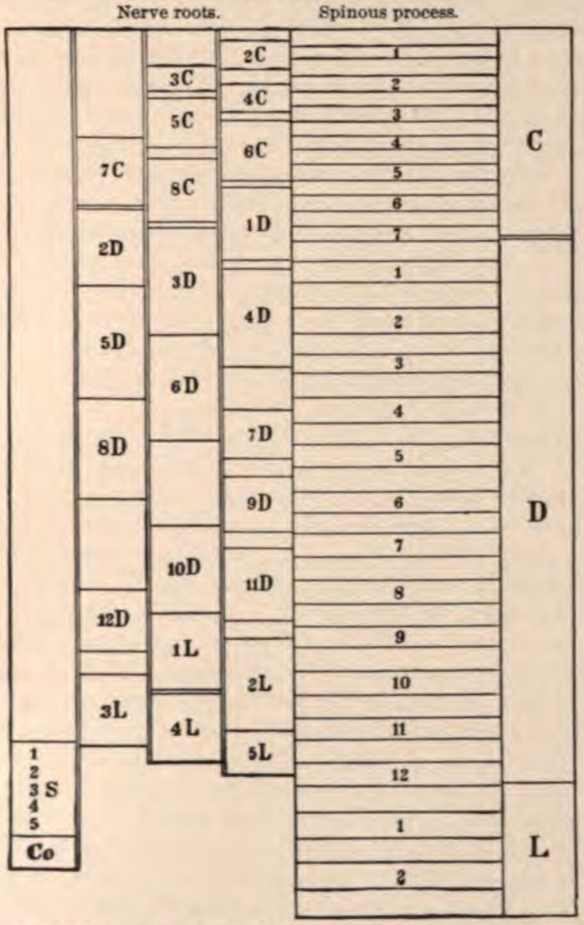
It would be of great importance from a diagnostic standpoint if it was possible to make use of the preservation of the reflexes in regions below the lesion. According to the views held at present, they should remain intact. However, experience shows that the tendon reflexes are usually absent throughout the entire region below the lesion, and that the remaining reflexes, especially the skin-reflexes, are so unreliable that their absence is of no diagnostic [illegible]. With an increasing horizontal process the surgeon may judge the level of the lesion from the signs of irritation present. The sensory signs are of especial importance. When the interruption is [illegible] the segment or root symptoms will be of chief value. In [illegible] interruption the symptoms referable to the long tracts combined with the upper segment symptoms will indicate the level of the interruption. If partial disturbance is combined with complete transverse lesions, their seat will have to be determined from the segment symptoms, i. e., from the roots and symptoms referable to the roots.

With motor symptoms the upper margin, which can usually be sufficiently determined, should be sought in the uppermost segment from which the muscles are supplied; and with complete paralysis of sensation at least the nerve-root immediately above must be [illegible], while with signs of irritation the upper margin is frequently supposed to be higher than it actually is, at least one or two segments. When irritation of the lower accessory roots is present, it may be transferred by communication not only to the main root, but to the upper accessory root as well. Considering the course of the roots within the canal, it may happen that a process interferes with a number of roots at a place considerably below the segment to which they belong. It is possible to refer the damage to the root to a segment much higher than the actual lesion. This error is comparatively uncommon, because the intravertebral roots are comparatively resistant and are less apt to give rise to symptoms than the cord.

It may sometimes be possible to discover the level of the process from visible or subjective and objective symptoms referable to the vertebral column. This applies especially to the bony canal, whereas all the other diagnostic aids refer to the localization of the focus of disease in relation to the cord itself. For the purpose of localizing these foci, the relation of the individual segments of the cord to the spines of the vertebræ must be known. This relation will be found in Reid's diagram. (Fig. [illegible].) It is evident that the relation between the vertebræ and their contents is not constant, but the localization is sufficiently accurate to furnish landmarks for surgical interference. In spite of the diagnostic aids, it is sometimes extremely difficult to locate a lesion in the cord. This can be done best with complete lesions, whereas with partial disturbance it may be impossible.

There remain to be mentioned several important symptoms depending upon the seat of the affection in the different sections of the cords. When a complete transverse lesion involves the upper four segments, death is due to suffocation, because the phrenic nerve, which arises chiefly from the fourth segment, and the intercostal nerves are permanently interfered with. A similar injury of the four lower cervical segments is not necessarily immediately fatal, although death usually takes place within a few hours, or at the utmost within a few days, due to insufficient respiration on account of paralysis of the intercostals. Meteorismus crowds the diaphragm upward, and the forced dorsal position combined with vasomotor paralysis leads to hypostasis, while expectoration is impossible on account of paralysis of the abdominal muscles. Partial lesions of the cervical cord may resolve and leave more or less evidence behind.

FIG. 229.


Nerve roots.
Spinous process.
2C
3C
4C
5C
6C
7C
8C
1D
2D
3D
4D
5D
6D
7D
8D
9D
10D
11D
12D
1L
2L
3L
4L
5L
1
2
3 S
4
5
Co
1
2
3
4
5
6
7
C
1
2
3
4
5
6
7
8
9
10
11
12
D
1
2
L

Regions within which the point of exit of the nerve-roots from the cord may be found in relation to the spinous processes. (Reid.)

The pupil symptoms are peculiar to lesions of the cervical cord. Increased perspiration over the entire body or over individual portions is also observed. The temperature may be very high or very low. The cause for this is little known. It is characteristic of cases in which the temperature rises above 43° C. that there are no other symptoms, and that the pulse remains normal. When the temperature drops abnormally the pulse-rate diminishes as a rule (25, Kocher).

The lower down the lesion, the greater the prolongation of life, although death usually follows in all cases, due to paralysis of the bladder with subsequent cystitis and pyelonephritis, or because of decubitus, which may occasionally open up the vertebral canal and produce purulent meningitis. The nuclear symptoms of lesions in the dorsal region are often not well pronounced, although in the lumbar portion of the cord they are again more definite.

The cord terminates at about the level of the first lumbar vertebra, so that processes lower down affect only the cauda equina. The fact that roots are affected which come from the lower portion of the cord explains why it is oftentimes impossible to locate the level of a lesion in the region of the lumbar vertebra from the nerve symptoms alone. It may be possible to distinguish a medullary lesion from a caudal lesion on the strength of the differences between diseases of the cord and affections of the roots. Severe sensory irritation is in favor of a caudal condition. The persistence of pain, even though transmission of impulses in the entire cauda has been interrupted, produces the clinical picture of paraplegia dolorosa. On the other hand, sensory paralysis cannot be associated with symptoms of irritation pointing to a lesion in the cord itself. Partial sensory paralysis is in the form of a lesion in the cord, although it may at times be found in connection with disturbances in the region of the root.

In chronic conditions in the region of the cauda the symptoms develop very slowly and sensory signs of irritation precede paralysis. As a rule the disturbance is not especially symmetrical, but is not unilateral. If the condition should be unilateral, then it is apt to continue so for a considerable time. In diseases of the cord itself it is quite common to have a unilateral stage. This does not last long on account of the rapid progress of all symptoms. The complete transverse section becomes involved, and the symptoms are then symmetrical. Motor paralysis appears early and degeneration of the ganglion-cells is frequently associated with fibrillary muscular twitching. Symptoms of sacral interruption in lumbar nuclear paralysis are positively indicative of lesions in the cord. The same applies to involvement of the first lumbar root because this is still in the region of the cord itself.

The lumbar roots of the cord, which are more external, are more apt to escape injury than the central sacral roots. Extensive disturbances in the cord itself are more likely to but need not necessarily involve both. When the lumbar disturbances predominate, the probabilities are that the lesion is in the cord.

In many cases important from a surgical standpoint the lesion is not a pure cord lesion, but a process which affects the cord and the roots at the same time. It is evident that this oftentimes makes the differential diagnosis still more difficult. If there is no sensitiveness to pressure over certain vertebræ and no other objective or subjective symptoms, it may be impossible to determine the level of the lesions. The roots behave just as the peripheral nerves, as far as their power of regeneration is concerned, and therefore lesions of the cauda may recover.

CHAPTER XXII.

DISEASES AND INJURIES OF THE MEMBRANES OF THE CORD.

DISEASES of the membranes of the cord are usually characterized by symptoms referable to the sensory nerves and the roots of nerves passing through them. Irritation of the sensory nerves gives rise to backache that may involve a considerable portion of the column, and is usually present when the patient is motionless. Motion increases the pain, so that the vertebral column is held stiff. Retraction of the neck, opisthotonos, and orthotonos are constant symptoms of meningitis. The former is not due to irritation of the spinal membrane, but is secondary to irritation of the cerebral meninges. The contracted muscles are oftentimes sore, and are always sensitive to pressure. The amount of contraction may vary. In slight cases there is limitation of motion; in severe cases the muscles are stiff and no motion whatever is possible. Involvement of the roots is indicated by symptoms of irritation. They are considerably pressed upon in extravasations, exudates, and tumors; paralysis may follow which involves several neighboring roots. Irritation of the sensory roots manifests itself in hyperalgesia of the skin and of the muscles supplied by them. There may be paræsthesia and neuralgic pains. Anæsthesia dolorosa is especially common when the nerve-roots are involved. Partial sensory paralysis is also observed in connection with pressure upon the roots.

Involvement of the motor roots will become evident from twitching of the corresponding muscles, although these symptoms are less constant than the sensory signs. During the period of irritation of the sensory root the reflexes may be increased as long as the motor roots are not paralyzed. The motor paralysis is flaccid and is rapidly followed by atrophy. Meningeal processes may press upon the cord itself and produce the clinical picture of lesions of the cord.

Hemorrhage (hæmatorrhachis) is the condition which is of chief interest surgically. This may be due to laceration of the large veins, rarely of the arteries, and is either extradural or intradural. Both varieties are probably always associated with grave disturbances of the cord itself and injury of the vertebral column. When the cord is involved, the symptoms referable to this organ will predominate. The hemorrhage has a tendency to extend downward within the vertebral canal, so that the symptoms may be more extensive the higher up the bleeding focus. The space into which the hemorrhage takes place is quite large, and an extravasation of blood usually does not exert much pressure because there is an abundance of room. For this reason the signs of compression of the cord in extramedullary hemorrhages are not apt to be marked, whereas the symptoms referable to the roots indicate that those widely separated from each other are involved. There may be sensory disturbances without motor symptoms, or the symptoms may be limited to the upper extremity, a condition which is of differential diagnostic value. The symptoms appear rapidly—apoplectiform. They are most marked at the end of twenty-four hours, but may become again exacerbated after two to four days, due to inflammatory reaction. They subsequently improve and disappear entirely after four to six weeks. Extradural and intradural hemorrhages may both be present at the same time, especially with perforating injuries, so that the blood may spout through the opening from one space into the other. The treatment consists in rest, horizontal position, ice-bags, and narcotics.

Inflammation of the meninges may take place inside or outside of the dura. The process of interest to surgeons develops in connection with injuries to the vertebral column or as a result of inflammatory processes in the vertebræ. In the latter case the inflammation is produced by the same organism that produced the lesion in the bone, while in the former the condition is usually the result of pyogenic infection.

Pachymeningitis externa (peripachymeningitis) is frequently associated with acute osteomyelitis of the vertebræ, and is still more frequently due to tuberculosis. There are first œdema and infiltration, and finally caseation of the dura, which in rare cases is ruptured. The disease involves the lymphatics in the dura that carry the lymph from the cord, and produces œdema of the cord (Kahker, Schmaus), a symptom which will be considered later. The condition is usually circumscribed and extends slowly in the loose peridural connective tissue. Pain in the back, rigidity of the vertebral column, neuralgia, hyperæsthesia, and muscular twitching may enable a correct diagnosis, which will in certain cases be supported by incidental disease of the column, such as caries or osteomyelitis. Œdema of the cord or the exudate can produce more or less extensive paraplegia, which may disappear, inasmuch as the tuberculous form of disease is not absolutely hopeless.

The treatment is directed toward the primary disorder, and will be considered in this connection. Intradural meningitis, pachymeningitis interna, and meningitis (leptomeningitis) are frequently associated. The arachnoid space offers special opportunity for extension of the process, which rapidly involves the entire region of the cord in infectious processes after perforating wounds. Even the cerebral meninges may be involved. These conditions are of interest to the surgeon from a diagnostic and prognostic standpoint. Recovery is not impossible.

Spinal tuberculous meningitis is not often due to extension from a focus in the vertebral column. The traumatic varieties are most important for the surgeon, such as those following perforating wounds or bedsores, or operative interference, and after rupture of a spinal bifida. The septic processes are associated with high temperature and often commence with a chill. Previous injury associated with meningeal symptoms will in itself indicate the diagnosis. In doubtful cases a lumbar puncture may decide the question.

Lumbar puncture was first made use of by Quincke in 1891 in a series of hydrocephalus cases. It was done for therapeutic reasons, the idea being to diminish the intracranial pressure. Lichtheim recognized the diagnostic value and was able to demonstrate the presence of streptococci in the fluid, thereby proving the presence of meningitis. The variety of bacteria will indicate the type of meningitis, whether tuberculous or purulent. Lately lumbar puncture has been made use of in connection with Bier's cord anæsthesia. The spaces between the third and fourth or fourth and fifth lumbar vertebræ are best adapted for puncture. The space between the fourth and fifth lumbar vertebræ is about on a level with the posterior superior spine. The fibres of the cauda equina easily escape the needle. The intervertebral spaces are broad and not especially covered by the spinous processes. They are widened still further by flexing the spine. Some authors prefer the space between the last lumber vertebra and the sacrum. The patients should lie on either side or sit upright and bend forward. Quincke introduces the needle a few millimetres to one side of the median line. Personally the author enters between the spinous processes upward and inward. A canula, about 0.6 to 1.2 mm. in diameter and about 5 cm. long, should be used. A trocar may also be used, although the hollow needle has the advantage that one sees immediately whether the dura has been perforated or not. The distance in adults is about 4 to 6 cm. and 2 cm. in children. A small glass tube held vertically is connected with the needle by means of a rubber tube. The level of the fluid in this tube indicates the pressure under which the cerebrospinal fluid is contained. Mercury manometers have been used for more delicate investigations. If the glass tube is lowered, the fluid runs out. Normally the pressure should vary between 40 and 125 mm. of water, although it may be higher without pathological change being present. A few cubic centimetres may be removed for diagnostic purposes. For therapeutic reasons it may be necessary to allow 200 c.c. to escape, although smaller quantities will usually be sufficient. Quincke endeavored to prevent infiltration of the peridural connective tissue with fluid by making a longitudinal slit with a narrow, lancet-like point attached to the hollow needle. Œdema of the soft parts showed that extravasation of fluid did take place. The use of anæsthesia as recommended at first by Quincke has been generally abandoned.

The treatment of meningitis depends on the primary cause. Great care should be taken to avoid infection of wounds in the region of the vertebral column, and when infection has taken place the area should be opened up freely and packed. Barth reports a case of traumatic meningitis in which lumbar puncture showed staphylococci. This case recovered after opening the vertebral canal and the dura at the site of operation, and two days later lower down for the purpose of drainage.

CHAPTER XXIII.

INJURIES AND DISEASES OF THE SPINAL CORD.

COMPLETE AND PARTIAL DESTRUCTION OF THE CORD.

THE subsequent course and symptoms of laceration and complete transverse contusion of the spinal cord need not be gone over again, because the remarks in reference to complete transverse lesions apply to these injuries also. As already mentioned, the prognosis of complete transverse lesions as regards the danger to life and restoration of function is unfavorable.

The results of partial injuries, such as laceration and contusion of nerve-fibres, must be separated from the secondary effects, such as the hemorrhage, which may be marked. Degeneration processes in the vicinity of the injured tissue always appear and may partially disappear. They consist at first in swelling of the axis-cylinder. (Enderlen.) The symptoms due to the primary lesion must be separated from those due to secondary changes. The former are irreparable, and are only partially overcome at times by the non-injured tracts performing the functions of the injured region. The group of symptoms due to secondary changes may disappear shortly after injury, and signs of improvement may be present after ten to fourteen days. Degenerative processes, however, may follow this improvement, or secondary inflammation may produce exacerbations which render the clinical picture irregular.

It seems to the author doubtful whether there is any local shock besides the symptoms due to swelling that complicates the clinical picture of trauma. He believes that the so-called concussion of the cord described as a purely functional molecular change without gross changes of structure, does not exist, because of the anatomical position and method of fixation of the spinal cord, which render concussion highly improbable. Again, a number of the conditions formerly supposed to be due to concussion of this sort have been demonstrated to be secondary to processes in the cord that could well be shown anatomically, such as traumatic necrosis of nerve-elements and hæmatomyelia. A certain portion of these, such as the psychic changes in connection with railway spine, are not localized in the cord at all, but in the cerebrum. The rapid disappearance of symptoms which are supposed to be characteristic of concussion, may follow with anatomical lesions, such as hemorrhages, as will be seen later. On account of these secondary changes, to which might be added extramedullary hemorrhage, the factors of differential importance between partial and complete injuries do not become evident in the early stages, and may not be apparent for several days after the injury. If at this time the reflexes are absent with paraplegia, and the motor paralysis of both halves of the body is approximately symmetrical, and when the sensory paralysis points to the same segment of the cord as the motor disturbance, with symptoms of paralysis of the bladder and rectum, it will be fair to presume that there is a complete transverse lesion. Persistence or reappearance of the tendon-reflex, or lack of correspondence between motor and sensory paralysis, asymmetry or incomplete paraplegia, are in favor of partial destruction. When the symptoms fluctuate, sometimes better, sometimes worse, and when they appear rather late, a partial lesion may be suspected. The presence of signs of irritation in the paralyzed region is in favor of partial injuries. Although theoretically impossible, the sensory signs may be due to irritation of the central end of the cord and peripheral projection of sensation, and the motor signs due to irritation of the peripheral stump or to skin-reflexes. Partial injuries may be produced by fracture, dislocation, and gunshot-wounds of the column.

STAB-WOUNDS OF THE SPINAL COLUMN.

Stab-wounds of the cord may be inflicted without damage to the bony canal, although at times the lamellæ or spinous processes are perforated. The cord is not always divided by the blade, and may sometimes only be contused, the dura remaining intact. The wound is almost always inflicted from behind.

Wagner-Stolper collected 86 cases of stab-wounds of the cord. Almost half of these were in the region of the neck; the rest were of the thorax, usually the upper part. The lumbar region was not involved. The thrusts are usually made from above downward, and the blade comes in contact with the vertebral column in the lumbar region at an angle that does not favor penetration of the canal. In the cervical region the cord is not so well protected on account of the relatively narrow arches that are considerably separated. The wound is usually in the median line or a few centimetres to one side. When the stab-wound is diagonal, the skin-opening is on the left side, while the right side of the cord is damaged. Injuries of this sort not infrequently are unilateral. In these cases secondary changes, such as swelling and hemorrhage, develop rapidly.

Symptoms.—The symptoms of stab-wounds appear at the moment of injury, and the individual collapses by reason of the paralysis. The majority of the wounds do not become septic, probably on account of the comparatively clean knife and slight laceration of tissue. The 20 per cent. of deaths is largely due to the lesion being high up or on account of complete or nearly complete transverse division of the cord. A certain number of deaths have been due to infection and meningitis, especially when the wound was inflicted through the mouth. Leakage of cerebrospinal fluid is by no means constant.

Prognosis.—Of 80 per cent. that lived, about 7.5 per cent. recovered completely according to Enderlen, and about 30 per cent. according to Wagner-Stolper. The remaining individuals improved. These figures indicate fairly well the prognosis, which is not rendered especially doubtful because of the danger of suppuration, and is chiefly affected by the location and extent of the damage.

Treatment.—The treatment consists chiefly in attention to the wound. Owing to the slight danger from infection, it is fair to presume that the wound is aseptic. It and the surrounding region should be cleansed to prevent secondary infection. It is evident that one should not pass a probe into the wound, although frequent errors are still made in this respect. When the subsequent condition of the patient leads one to suspect infection, the wound should be enlarged, and if necessary the vertebral canal opened and the whole region packed.

HÆMATOMYELIA.

The hemorrhage in injuries to the spinal cord is usually not severe. In rare cases, however, symptoms of hemorrhage may predominate, especially when the bleeding takes place in connection with injuries producing but slight destruction of the nerve-tissue itself. The name hæmatomyelia is applied to this condition. Occasionally the same clinical picture is produced by non-traumatic condition. The author will, however, confine himself to the descripton of the traumatic variety.

Hemorrhage usually takes place into the soft vascular gray substance (central hæmatomyelia), although the white substance is not exempt. There are either a number of individual hemorrhages, or one single hemorrhage which may spread in the gray substance, as offering the least resistance, and produce extensive paralysis. This forms a so-called tubular hemorrhage.

The primary cause of traumatic hæmatomyelia seems to be stretching of the cord in sudden movements of the column. The bony canal itself may remain intact, or be fractured or dislocated. Powerful traction in the direction of the cord, as in forceps delivery, may produce a similar condition. Contusions are rarely followed by extensive hemorrhage, perhaps on account of the laceration of the vessels. Hæmatomyelia is generally found in the more movable portions of the vertebral column, especially in the cervical region, where the cervical enlargement is the seat of election, evidently on account of the abundance of gray substance. Cases of hæmatomyelia have also been reported in the lumbar enlargement, and the only case reported in the dorsal region (Bender) is not beyond question.

Symptoms.—The symptoms are produced by destruction of nervous elements, the effect on neighboring regions, and the pressure of the extravasated blood. The first symptoms appear at the moment of injury, but may be absent if the destruction is slight or affects an unimportant portion of the cord. Hemorrhage takes place rapidly, and as a rule reaches its limit within the succeeding few hours, even while the physician is watching the case (apoplectic, Kocher). Later the local reaction produced by the hemorrhage not infrequently complicates the clinical picture by aggravating the symptoms. The signs of destruction are permanent. Those of pressure are temporary in part at least. The latter usually disappear early, and within a few days signs of distinct improvement are observed. The pressure of extravasated blood, of course, may produce irreparable damage.

The symptoms differ in no way from those produced by other varieties of complete transverse injury. The manner of development and the disappearance of symptoms, and the nature of the injury, will enable a correct diagnosis. The hemorrhage may involve any portion of the transverse section and produce correspondingly differing symptoms. The seat of election of hæmatomyelia is the gray substance, as is evident from the symptom-complex. Changes in the temperature and pain senses are noted especially (Minor), as is atrophy of the paralyzed muscles whose nuclear region has become involved, therefore usually of the arms (diplegia brachialis).

Extension of the hemorrhage and pressure, even when the gray substance alone is involved, may produce complete paraplegia or temporarily a condition resembling a complete transverse lesion, while with unilateral hemorrhage the condition may resemble complete unilateral destruction of the cord. The damage to the conducting fibres, which affects chiefly the long tracts and the motor ones more than the sensory regions, will be more prominent in the early stages than the results of nuclear paralysis, because only individual groups of muscles are paralyzed, and not entire extremities. Pain in the back is frequently felt corresponding to the seat of the hemorrhage, which is due to injury of the posterior roots or posterior horns. Violent symptoms of irritation, radiating pains, sensitiveness to pressure, and rigidity of the affected section of the column, would favor hæmatorrhachis, which may, of course, be combined with hæmatomyelia.

The prognosis of hæmatomyelia is relatively favorable, because the process is apt to resolve rapidly. When the lesion is high up, paralysis of respiration may result fatally, or when the condition lasts for any length of time the same result may be produced by complications, such as cystitis, pyelitis, or decubitus. With slight injuries complete recovery is possible, although as a rule there remain signs of the primary or secondary destruction, which often causes symptoms referable to the region affected.

The symptoms produced by hemorrhage into the gray substance are sometimes the same as those described in text-books on internal medicine, and attributed to syringomyelia. It is not improbable that this central gliosis and cavity formation may be secondary to hæmatomyelia, because the lesions produced by injury may become filled with gliomatous tissue, which later undergoes cystic change. Schmaus claims that cavities develop following injury to the cord, due to circumscribed softening, and on account of degeneration of newly formed

[illegible]

[illegible]

COMPRESSION OF THE SPINAL CORD BY LESIONS OF THE VERTEBRAE

[illegible]

[illegible]

[illegible]

[illegible]

gliomatous tissue. Wagner-Stolper believe that stretching of the cord produces small fissures without extravasation of blood.

Nauwerck and Bawli have demonstrated that there may be some connection between syringomyelia and trauma. Bawli reports that about 11 per cent. of 267 cases of syringomyelia had a history of previous injury, and believes that this number is too small because of carelessness in obtaining a history of trauma. Lax, Müller, and Wagner-Stolper each report a case. Traumatic syringomyelia occurs most frequently in the regions of the cord corresponding to the portion of the vertebral column most often the seat of fracture—*i. e.*, in the lower dorsal and lumbar regions. Hemorrhage and non-traumatic syringomyelia, on the other hand, are more common in the cervical region. This shows sufficiently that hemorrhage alone is not the communicating link between trauma and syringomyelia.

COMPRESSION OF THE SPINAL CORD IN CARIES OF THE VERTEBRÆ.

By far the most common disease of the vertebral column is tuberculosis, which leads in many cases to cord symptoms. It has already been mentioned how the cord becomes involved, and that as a rule peripachymeningitis develops, which at first gives rise to œdema of the nerve-elements on account of obstruction to the flow of lymph. Later the generative processes develop. Myelitic processes are due to reaction. It has been mentioned that recovery may follow after years of paralysis.

Compression due to abscesses, masses of granulation-tissue, or displacement of the vertebræ is comparatively rare. Occasionally following slight trauma the latter condition may suddenly give rise to symptoms. The condition of the cord corresponds to that of traumatic origin, and when the upper cervical region is involved death may take place immediately.

Progressive tuberculous myelitis extending from the primary focus is uncommon.

There is usually the clinical picture of partial destruction of the cord, beginning with weakness and finally leading to complete paralysis. The paralysis may be symmetrical, or may be more pronounced on one side of the body, and in rare cases it may even be unilateral. The transverse section of the cord is rarely completely interfered with, so that it is not common to have a clinical picture of complete transverse lesions. The bladder and rectum are involved in a manner already described. Root symptoms may be present, such as more or less violent neuralgic pain, although this symptom may be slight and disappear entirely when the column is placed at rest. These symptoms have a tendency to disappear rapidly, probably because the process extends quickly and the function of the roots becomes obliterated.

COMPRESSION OF THE CORD BY TUMORS.

The lesions of the cord produced by tumors are of special interest to the surgeon, because a number of the conditions may be relieved by operative interference. The term tumor is used in the widest sense of the word, and not in the strictly pathological sense. Besides the true tumors, inflammatory processes that produce swelling, such as abscesses and parasites, belong to this group. L. Bruns divides these tumors into such that develop primarily in the membranes of the cord and involve the cord itself secondarily, and into the intramedullary tumors. The former group is again subdivided into vertebral and intravertebral.

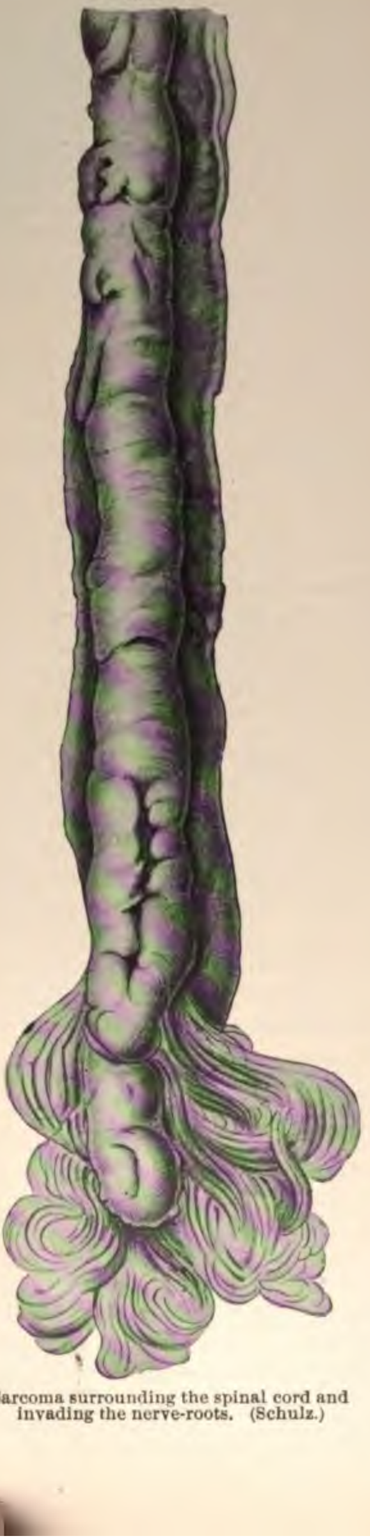
1. The vertebral tumors to which belong practically the majority of the swellings in the vicinity of the vertebral column that involve the cord secondarily will be considered later in connection with diseases of the vertebra. The effect of these conditions on the cord is similar to that of caries of the spine. Eventually œdema and deformity of the column develop with secondary signs of compression of the cord. The latter may appear suddenly in connection with trauma. Even in very malignant tumors it is rare to have the dura involved and the cord itself infiltrated by the growth. Malignant tumors, not only the primary but also the metastatic, usually originate in the vertebræ, and therefore are more likely first to involve the roots by pressing upon these in the canal itself or in the intervertebral canal. Sometimes they are directly infiltrated. The anterior and posterior roots are affected with about equal frequency, and the symptoms appear in both halves of the body more or less symmetrically. Symptoms due to involvement of the roots are therefore quite common with tumors, and may dominate the clinical picture. The first sign is usually evidence of irritation affecting the sensory region. Neuralgia, hyperæsthesia, and paræsthesia are observed, and sometimes evidence of motor irritation, spasms, or contractions, and trophic disturbances, such as a glossy skin and herpes zoster.

Paralysis as a symptom of involvement of the roots is relatively uncommon, and is more apt to involve the motor than the sensory region. Sensory paralysis is apt to present the characteristics of anæsthesia dolorosa.

The cord symptoms, which may follow the root symptoms, after a considerable time take on the character of a paraplegia dolorosa on account of the persistence of symptoms due to involvement of the roots (Cruveilhier), and they differ in no way from those produced by pressure-paralysis.

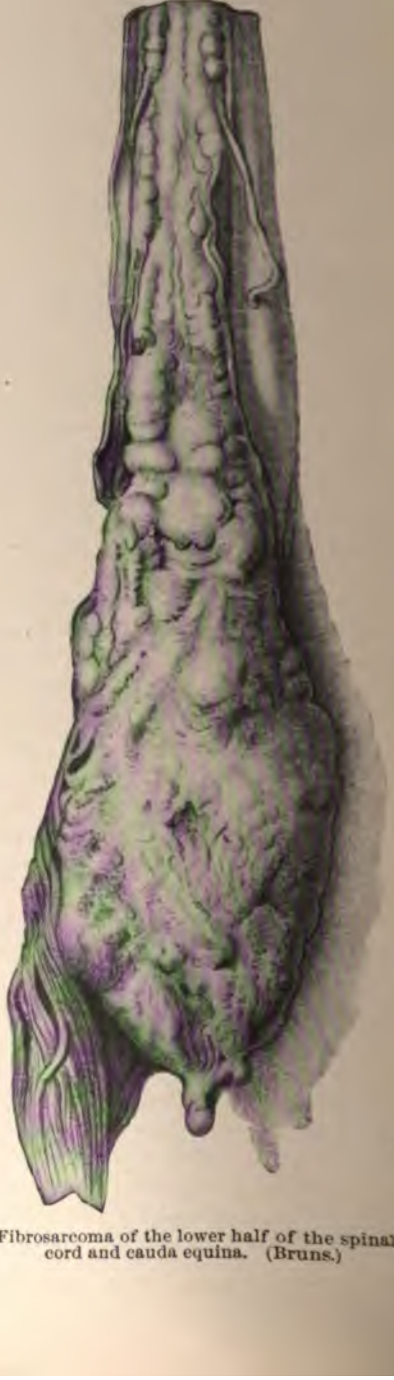
Complete lesions are uncommon, even complete unilateral lesions. The disturbance is usually approximately symmetrical, and prevents the development of this condition. It will be seen that the symptoms referable to the roots and cord in caries of the spine resemble closely those due to vertebral tumors. It is not always possible to distinguish these conditions from the nervous symptoms alone. Violent

Fig. 230.



Sarcoma surrounding the spinal cord and invading the nerve-roots. (Schulz.)

Fig. 231.



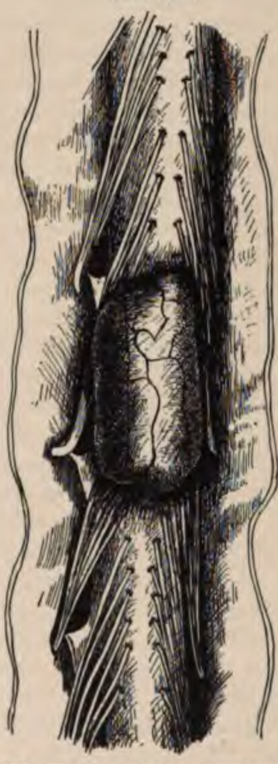
Fibrosarcoma of the lower half of the spinal cord and cauda equina. (Bruns.)

and prolonged root symptoms favor tumor, whereas disappearance of the symptoms favors caries. The differential diagnosis will be based upon the history and upon the symptoms referable to the spine itself.

2. Intravertebral tumors may be intramedullary or intradural and extradural. Those situated between the dura and pia are of especial interest to the surgeon, because the diagnosis is more frequently possible in these cases, and operative interference is more liable to be successful. Extradural tumors are not always unfavorable; whereas the intramedullary, being the most difficult to discover, are beyond surgical interference.

The varieties of intramedullary tumors to be mentioned are glioma, sarcoma, tuberculous, gumma, cysts. Sarcoma and gumma usually develop in the pia and involve the cord, whereas the others develop in the cord itself. The primary extradural tumors are lipoma, sarcoma, enchondroma, tuberculous abscesses, masses of granulation-tissue, and echinococcus cysts. Carcinoma, sarcoma, and teratoma may cause metastases in this region. All these tumors usually spread along the surface in the extradural tissue without compressing the cord very much at first. The dura is rarely perforated, and tumors may persist for a long time without producing symptoms other than those referable to the nerve-roots.

FIG. 232.



Fibroma lying on the spinal cord. removed by McCosh. (Starr.)

The intradural tumors may develop in the firm and delicate meninges that in approximation from the arachnoid tissue from the ligamentum denticulatum, and finally from individual nerve-roots or from their surrounding membranes. Fibroma, lipoma (the latter in connection with spina bifida), angioma, psammoma, neuroma, and neurofibroma are also observed. The latter are often multiple and develop in the roots. Varieties of sarcoma, such as fibrosarcoma, myxosarcoma, or pure sarcoma, have been reported. Sometimes a general sarcomatosis of the delicate membranes develops, which may even involve the pia of the brain. Other kinds of tumors, except the neuroma and neurofibroma, are usually single. Echinococcus cysts are comparatively rare, although cysticercus is more common and sometimes multiple. There may be circumscribed or multiple nodes of tuberculosis or syphilis, especially of the latter, any of which may give rise to diffuse meningitis.

The diagnosis of intravertebral tumors is frequently possible because the growth is apt to develop in a typical manner and cause more or less characteristic symptoms.

a. The intradural processes, corresponding to their primary seat, usually involve first of all the roots passing through the dural space. Symptoms due to pressure upon the cord develop comparatively late, especially as the growth enlarges slowly and is frequently benign. Symptoms referable to the column, such as sensitiveness to pressure, may be absent or appear late in the disease. The condition may be recognized in a certain number of cases on account of the position of the tumor. As a rule they are situated to one side or toward the back, but rarely in the median line in front or behind, and frequently produce cord symptoms resembling unilateral lesions. After they have existed for a considerable time paraplegia may develop. Corresponding to the shape of the space in which the intradural tumors develop, a mass which is primarily spherical gradually becomes cylindrical, which explains how the root symptoms may indicate involvement of several segments without marked pressure-symptoms upon the cord itself.

Symptoms due exclusively to involvement of the roots may persist for two years or longer. Hyperæsthesia and neuralgic pains are violent. Coughing and sneezing increase the agony. The attacks are of long duration. After destruction of the root, produced by compression or infiltration, the symptoms may diminish, but increase again when fresh roots become involved by the process. Symptoms of motor irritation are more uncommon, partly because the tumor is usually situated in the posterior region of the cord. If symptoms of paralysis develop, they appear first in the motor region.

The cord after a considerable length of time becomes compressed. The pressure may persist for some time before softening and irreparable damage become evident. The pia forms as a rule an insurmountable barrier to direct involvement of the cord, which in the case of tumors takes place only when the pia itself is the primary seat of disease. Death in these cases is usually due to pressure upon the cord; either important centres are damaged or secondary conditions, such as decubitus and cystitis, develop. Corresponding to the slow development of the tumor, the symptoms referable to the cord appear gradually. Motor paralysis of the legs appears and gradually extends upward, whereas the area of sensory paralysis is not so evident and usually makes its appearance with symptoms of complete transverse destruction. From the moment the cord becomes involved the evidence of progressing disease becomes more marked than during the period when symptoms referable to the roots alone were in evidence. One must be careful not to overlook the various stages of the disease, especially the period when the lesion is unilateral. Occasionally pressure upon the cord may increase rapidly on account of hemorrhage into the cord or because of œdema, conditions which may arise in the tumor itself, and which may be followed by signs of complete transverse destruction or immediate complete paraplegia. The sensory root, whose segment has been destroyed, no longer gives evidence of sensory irritation, although fresh areas become involved by extension of the tumor upward. The region of complete motor and sensory paralysis is marked off above by a region of sensory irritation which may be unilateral. The same applies to the motor roots in a modified way.

Symptoms due to involvement of the vertebral column, such as rigidity, localized pain, and sensitiveness to pressure over the individual spines, may be absent, but when present may be of value in indicating the level of the disturbance.

b. The differences in course between intradural and extradural tumors are easily understood. Extradural tumors on account of their tendency to extend longitudinally involve many roots before producing symptoms due to pressure upon the cord itself, more so than is the case with intradural tumors. The preliminary neuralgic pain may be of protracted duration. Schultze has recently described a case of extradural fibroma in which symptoms of pressure upon the cord were absent for eight years. In extradural tumors, on the other hand, the bone is more apt to be involved early and over a large area. In spite of the late appearance of symptoms due to pressure upon the cord, the average duration of the disease is shorter with extradural tumors than with intradural, probably because the former are more likely to be malignant processes.

c. Intramedullary tumors are the least typical and often cannot be recognized. The symptoms are referable, of course, to the region of the cord involved. Not infrequently there will be disconnected regions of sensory paralysis. The stage of root symptoms may never make its appearance. These tumors cause early alarming cord symptoms.

The diagnosis of intravertebral, and especially of intradural tumors may frequently be made with reasonable certainty if the condition has been present for a considerable time and produced persistent signs of irritation and later evidence of paralysis due to involvement of the roots, and finally compression of the cord. The diagnosis will be especially accurate when there is evidence that the root symptoms have persisted for a length of time on one side, and when the cord symptoms were temporarily similar to those produced by unilateral lesions. The presence of symptoms referable to the vertebral column itself will confirm the diagnosis if they are at a level where it would be supposed that the cord and root disturbances should be found. The probability of a tumor is increased when there are neoplasms in other regions of the body which make it possible that a growth of a similar character is in the vertebral column.

Peripheral neuralgia is of differential importance during the stage of root symptoms. The very violent character and persistence of this symptom, the absence of typical areas sensitive to pressure, the increase of pain with motion, sneezing, and coughing, and the radiating character, will all be in favor of an intravertebral growth. The same applies to the appearance of paralysis or symptoms referable to the cord.

The nervous disturbances produced by tuberculosis of the column consist of symptoms due to irritation of the roots, but last for a considerable time only in exceptional cases, because the inflammatory processses progress much more rapidly than the majority of tumors in this region, and rapidly pass beyond the stage of root irritation. A clinical picture resembling unilateral lesions is also uncommon. If there are symptoms bearing directly upon the vertebral column itself, or if abscesses are present, there will be no doubt about the diagnosis. The improvement that sometimes takes place does not correspond to the clinical history of tumors in the strict sense of the word.

Pachymeningitis hypertrophica is a condition which usually develops in the lower cervical region and is probably of syphilitic origin. This condition may for some time produce symptoms referable to the roots alone. The process is usually circumscribed and the symptoms resemble those of a tumor only when the region involved is very extensive, but this extensive involvement does not point to tumor on account of the absence of pressure-symptoms upon the cord. Rigidity of the portion of the spine affected is often the only symptom present, a sign that may be absent with tumors.

The fact that the diagnosis of a tumor is made largely on account of the slow development of symptoms is the reason why intradural benign tumors are those more likely to be detected. Slowly developing extradural new growths may produce a sufficiently characteristic picture, while with intramedullary processes the diagnosis is possible only in exceptional cases. When considering the treatment it will be seen that surgical interference is most successful in cases in which an absolute diagnosis is possible.

Up to the present the diagnosis of a tumor has been considered without regard to the variety. As a rule it is impossible to differentiate the growth. The nervous symptoms are of no value in this direction. Rapid advance of symptoms is characteristic of malignant tumor, but is also observed with inflammatory swellings or syphilitic and tuberculous conditions. Evidence of the latter diseases in other regions of the body is of more or less significance, and the presence of primary tumors or metastases in other locations is also of value. If it is possible to determine accurately whether the growth is extradural intradural, or intramedullary, one will consider the tumors which are most common in the region affected. If spina bifida is present, the possibility of a lipoma should not be forgotten. Without interference the prognosis in true tumors is hopeless. The inflammatory processes may sometimes be improved without operative treatment. This subject will be considered later.

TREATMENT OF INJURIES AND DISEASES OF THE SPINAL CORD.

It is evident that in the vast majority of cases it will not be possible to obtain complete recovery after injuries of the spinal cord, for the destroyed nerve-elements of the cord are restored only to a very slight degree if at all. The conditions are different after compression.

The paralysis produced by pressure may disappear after the pressure has been removed. In these cases surgical interference is very satisfactory.

Those cases in which the condition of the cord itself cannot be improved may frequently be relieved symptomatically. It is often possible to alleviate the discomfort and prevent dangerous secondary complications of paralysis and prolong life where the paralysis is only temporary.

Pain should be combated with narcotics, especially with morphine. Neuralgic pains demand the use of antipyretics, such as phenacetin, etc. Sudorifics, such as bromides, chloral hydrate, sulphonal, and trional, are necessary at night. Morphine should always be given in cases that are liable to terminate fatally within a short time. The alleviation of pain and preservation of strength must be aided by tonics, iron, etc.

The bowels should receive special attention. In many cases of paralysis of the sphincter retention develops on account of the paralyzed abdominal muscles. In a certain sense retention is of value, because frequent saturation and wetting with urine and fecal matter macerate the skin and favor decubitus. Sometimes opium will be indicated. On the other hand, there is danger from hard fecal accumulations producing suppuration of the intestinal mucous membrane. In many cases it may be so arranged that no movement takes place for several days (four or five), and on the next evacuation the bowels should be thoroughly cleansed. Laxatives and enemata are frequently insufficient, especially if the latter do not come away, so that it may be necessary to free the recum mechanically.

In the majority of cases there is retention of urine which is sometimes overcome by intermittent discharge from the bladder. Stretching of the sphincter is due to overdistention of the bladder. Rupture of the bladder does not take place, but the mucous membrane suffers, especially the epithelium, and the development of cystitis is favored. One should never permit the retention to become extreme, and care should be taken to empty the bladder at a time best suited to the individual case. Especial attention should be paid to this part of the treatment, because with patients whose innervation is defective there is no sensation indicating distention of the bladder, which can only be detected by palpation and percussion. In all cases of true paralysis one is obliged to resort to the catheter. It will be necessary to follow Kocher's advice and provide for permanent drainage only when there are difficulties in introducing the catheter to which one does not wish to expose the patient too frequently. Permanent drainage may be necessary with patients who are not under constant observation. Wagner-Stolper's objection that constant drainage catheters favor ulcers of the urethra and the formation of calculi is not without foundation.

Pressing the urine out of the bladder which Kocher recommends in cases in which the lesion is not in the cervical or upper dorsal region of the cord, is not without danger, and may not be possible in the early stages of the disease. The dangers of cystitis are great. The damage done to the bladder-wall in vasomotor paralysis by the use of a catheter, combined with retention of urine, and auto-infection from decubitus ulcers may produce ascending urethral inflammation leading to cystitis, which if once present is difficult to combat on account of the persistence of the obnoxious causes. The inflammation may progress frequently from a simple catarrhal inflammation to the most severe ulcerative and membranous processes and lead to infection of the pelvis of the kidney and of the kidney itself.

The treatment of cystitis will be considered elsewhere. The utmost should be done in the way of prophylaxis.

Decubitus is another complication which it is difficult to avoid in long-continued cases of paralysis. The best way of preventing an ulcer is suspension in a bath, which is oftentimes impossible, however, on account of complications in the column, such as fracture, and is unsuccessful even in other cases. Prophylaxis should be strict, so as to preserve the resistance of the skin or increase it if possible, and pressure over prominent regions of the body should be prevented.

Cleanliness is of paramount importance. The patient should be frequently washed with cool water and soap. Dilute solutions of vinegar or lemon juice have also been recommended. The skin should be carefully dried after the use of alcohol or spirit of camphor, and powdered. If it is impossible to keep the patient dry, the skin should be protected with mild salves, such as boric acid ointment. Local pressure is best avoided by the use of water cushions. The cushions should be filled sufficiently to raise the patient so that he barely touches the sheet. The care of the bed is of extreme importance, because folds favor the development of bedsores. Small rings should be placed beneath the heels or under any region that becomes reddened. The pressure of the bedclothes should be borne by cradles. If possible, the position of the patient in bed should be changed from time to time. Local applications may often abort threatening bedsores. If ulcers develop in spite of all precautions, they should be treated according to their character. Suppurating gangrenous tabs will frequently disappear after the use of aluminum acetate poultices. Pus should be freely drained by incision. Gangrenous portions should be removed, but care should be taken not to cut into healthy tissue more than is absolutely necessary. In many cases antiseptic dressings will, if dry, produce better results. Granulating surfaces may be covered with boric acid ointment or silver nitrate, balsam of Peru, and zinc ointment mixed in the proportion of 1 to 2 : 100.

The permanent bath is the best method of treating existing ulcers. When patients do not object, they should be placed in a bath and if possible taken out only for a few hours at a time.

In cases in which there is hope of improvement or a recovery one should pay early careful attention to the paralyzed limbs and endeavor by passive motion to avoid stiffening of the joints. Contractures should be avoided by careful attention to the position of the extremities. It is doubtful whether the galvanic current is of value. There is no doubt that careless use of the constant current may easily produce gangrene, because the pain is not felt owing to the sensory paralysis. An interrupted current may be of more value in preventing paralyzed muscles from becoming atrophic because of disuse. In the after-treatment efforts should be made to hasten the disappearance of the paralysis with electricity and massage. This latter procedure is not well borne with extensive paralysis, and may damage the muscles and favor furunculosis of the skin that is massaged.

It is justifiable to speak of treatment of paralysis of the spinal cord proper only when the therapeutic measures are able to remove the pressure. In a number of cases this disappears spontaneously. In hæmatomyelia the hemorrhage becomes absorbed and with partial injuries the swelling of the axis-cylinders in the surrounding region disappears. In both cases there remains the disturbance which is produced by the direct destruction of tissue. In these cases rest is indicated, as is also treatment of the vertebral column, which is usually damaged. Not infrequently steps must be taken to remove the pressure on the cord. In fractures of the vertebræ and dislocations reduction of deformity and extension in the corrected position may be of value. In tuberculosis the paralysis sometimes disappears with rest in bed and extension, and in syphilitic processes appropriate treatment often gives the desired result. These therapeutic measures do not always give relief and operative interference becomes necessary just as in the treatment of tumors and parasites, etc.

Laminectomy was first done by Macewen in 1886 for fracture and later for caries. Horsley and Gowers in 1887 were first to remove successfully a tumor of the spinal cord. The operation is simple. The vertebral canal is opened by removing one or more vertebral arches. An incision is made longitudinally over the spinous processes of the vertebra to be attacked. The periosteum is then lifted off on both sides and pushed back. The same is done to the periosteum of the arches at the base of the spinous processes. The amount of hemorrhage is often considerable on account of the large number of muscular branches divided. The larger vessels should be tied, but the smaller ones usually stop bleeding on account of the pressure from retractors. The exposure of the vertebra to be resected should be as perfect as possible. The next step is difficult, because in opening the canal the cord may be injured on account of the diminution of the lumen. A chisel cannot be used, because of the possibility of driving the fragments into the cord. It is best to bite off the outer portion of the lamellæ and divide the remaining inner portion with bone-cutters. The tendency is to divide the arch at the side of the spinous process and remove the central piece at one time. It is much quicker, however, to remove the spinous process with Billroth's cutters (Fig. 233) and open in the median line or near by. This may be done with a narrow pair of curved cutting forceps as shown in Fig. 234. If a gap has been made, resection of the lateral portion is not difficult, because one is able to see the cord and protect it against injury. Sometimes it may be necessary to enlarge the skin-incision and remove other vertebral arches. Urban's method of temporarily resecting the arches of the vertebræ has been extensively made use of because the method is not complicated, and because sufficient room can often be obtained by removing the arches themselves. (Israel.) Urban recommends the use of a U-shaped incision with the base downward in the cervical and upper dorsal regions and upward in the lumbar region. The incision is carried down onto the transverse processes and the vertebral arch divided close to the body of the vertebra and turned back with the skin and muscle flap. After once opening the vertebral canal Urban makes use of a chain saw. The number of incisions increases the amount of hemorrhage and complicates the operation. Opening the vertebral canal with a chisel may be avoided, as recommended by L. Bruns, by sacrificing the first arch resected. The subsequent arches to be divided are attacked with the chain saw or with a narrow bone-saw. The author does not consider it advisable to use a chain saw at first, because there is no guide that prevents injury to the cord. It is not always easy to pass this instrument under an arch, and when the lumen is diminished damage may be unavoidable. Urban's suggestion deserves consideration, because the absence of a larger number of vertebral arches may be followed by severe disturbances. Patients have not been able to sit upright or to hold their heads up. Conditions of this sort are avoided by osteoplastic resection or preservation of the periosteum. (Ollier, Smits.)

FIG. 233.

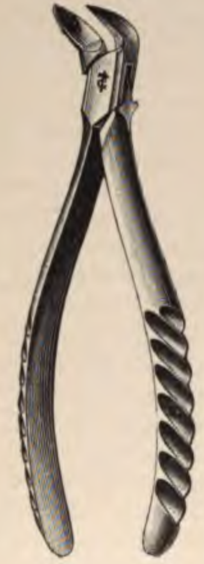


FIG. 234.

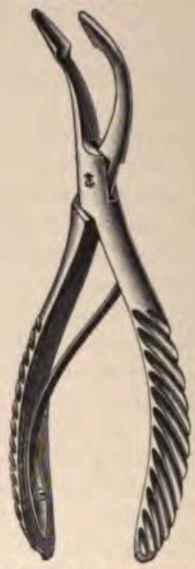
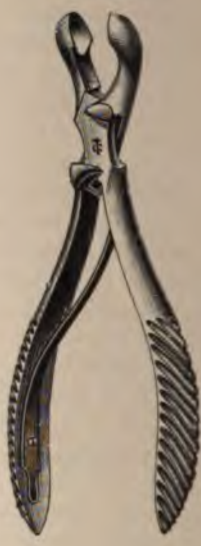


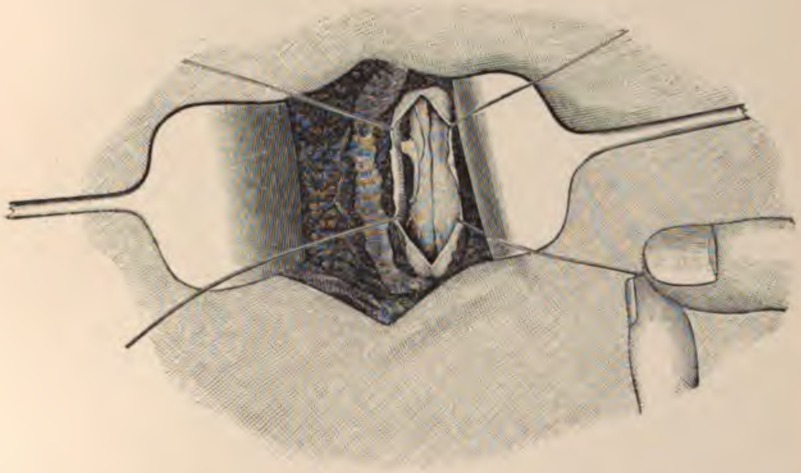
FIG. 235.



Bone forceps for laminectomy.

Hadra recommends uniting the neighboring spinous processes with wire sutures, and Chipault uses wire loops that include the arches and transverse processes for the purpose of overcoming this after-effect. The further steps of the operation depend upon the conditions found. An effort should be made to remove extradural processes, tumors, echinococcus cysts, etc., if possible, even if the opening has to be considerably increased. If there is disease of the vertebral arch, such as an exostosis, for instance, the laminectomy itself will be sufficient. If the pressure on the cord is produced by fractured arches, the operation is at an end as soon as the fragment has been removed. If several arches are depressed, it may be possible to raise them through the first opening in the canal. If this is not possible, they must be resected. When it is desirable to reach the region of the body of the vertebra, the dura and spinal cord should be drawn to one side with great care. Sometimes this is only possible after division of one or two roots on the opposite side, which should, however, be subsequently reunited. The exposure should be sufficient to enable one to remove with a chisel masses of callus or bony angularities.

FIG. 236.



Laminectomy with opened dura.

When the disease is intradural, the membrane should be divided by a longitudinal incision and retracted with small sharp hooks or silk sutures passed through the edges. (Fig. 236.) Cerebrospinal fluid commences to flow immediately on opening the dura. Normally one should now be able to see the posterior surface of the cord, covered only by the fine meshwork of arachnoid. The lateral surfaces may be inspected by pulling the dura to one side. For the purpose of viewing the anterior surface it may at times be necessary to sacrifice several roots. Generally speaking, the removal of an intradural tumor is not especially difficult. They are usually benign encapsulated growths, and are commonly found in the posterior or lateral region. If one of the roots is embedded in the tumor mass, it should be sacrificed.

Chipault has recommended a method of uniting the cord in complete transverse lesions with sutures involving the pia. These attempts are usually futile, not only on account of the slight power of regeneration in the cord, but also because it may not be possible to bring the soft cut surfaces together because of the marked retraction. The sutures in the pia give way on the slightest pressure. It may be more advantageous to suture the roots immediately above and below the lesion. Experiments on dogs have shown this to be a fact, but even under the most favorable conditions it is not possible to get accurate apposition of the stumps. After completing the intradural portion of the operation the wound is carefully closed with several layers of sutures. The first layer approximates the edges of the dura as closely as possible. The longitudinal muscles of the back are held together with catgut and the skin sewed over these. As a rule there is no need of packing or draining the wound. Secondary hemorrhage is avoided by the layers of stitches and strict asepsis is always necessary. Only in operations for the purpose of draining an already infected wound is it well to make use of iodoform gauze drains, and when there is uncontrollable hemorrhage from the vertebral canal it may be necessary to pack down to the base of the tumor. This packing may be removed within a few days and the wound closed with secondary sutures.

The skin of the back is frequently difficult to sterilize on account of bedsores and the paralysis of the bladder and rectum. A method made use of in the clinic at Breslau will be mentioned here which endeavors to exclude the skin from the field of operation. After incising the skin the back is covered with a piece of boiled oiled silk with a slit corresponding to the length of the skin-wound. The margins of the cloth are sewed to the subcutaneous tissue or held in place with clamps about 2 cm. apart. After fastening this material, which is water and bacteria proof, in place, it should be covered with towels that can frequently be changed. The gloves should be changed and fresh instruments used. This oiled silk covering need not be removed until it is time to close the skin. In this way the operation will in all probability be aseptic, and it is reasonable to suppose that the wound will close by first intention. There is always danger of secondary infection when the wound is left open.

The indications for doing laminectomy will be considered later in connection with diseases of the vertebral column, trauma, caries, and tumors.

As yet there is no uniformity of opinion when to operate in traumatic conditions of the cord. If it is called to mind what has been said regarding the power of recuperation in injuries to the cord, it will become evident that the only benefit derived from an operation is the removal of pressure. The feeble power of regeneration cannot be improved by operative interference, and complete division and laceration of the cord are in no way improved by surgical interference, which should therefore be avoided. Even with partial injuries the destroyed portion cannot be restored, whereas the symptoms due to hemorrhage and swelling may disappear spontaneously or leave evidences of degeneration which the surgeon is powerless to remedy.

The question arises whether the pressure on the cord in these injuries is not due to diminution in the lumen of the canal. Experience shows that this is infrequent, especially if the injuries to the spine are treated with extension. Under this form of treatment the paralysis developing as the result of partial injuries may disappear. On the other hand, it may be said that the good result supposed to have followed early operation would have taken place even without surgical interference. It is impossible to judge of the severity of the cord lesion during the first hours or days after injury. If an operation is performed at this time, one frequently discovers that no advantage is to be gained, and that those cases which have a tendency to recover spontaneously have been subjected to additional dangers. The author will consider later the prognosis of laminectomy in general. There is no doubt that a certain number of the patients operated on die as the result of the operation, and it is always to be feared that with early operation the number of patients that die as the result of the operation, which would otherwise have recovered, is as large as the number of these that die as the result of expectant treatment.

If the patient is watched and symptomatic measures applied, those that have partial injuries will gradually improve. Of course, those that improve without operation should not be subjected to surgical interference. Their improvement is proof that an operation is unnecessary. If, on the other hand, there are factors which continue to produce damage in a partially injured cord, they will soon make themselves evident. If the early improvement ceases or if the condition becomes worse, it is justifiable to consider that this change for the worse is due to continued pressure, and it becomes the surgeon's duty to remove this as soon as he can. Operations that have been performed in this direction have at times been followed by brilliant results. Experience shows that in the majority of cases that are improved by operation there have been depressed fractures of the arches. It will be seen later that with this injury continued pressure is frequently associated with contusion. This fact has led the majority of surgeons to operate immediately when fracture of the arches is associated with cord symptoms. These injuries are not infrequently complicated with wounds which may favor one's decision to interfere. In cases of the sort one is frequently obliged to make large incisions for the purpose of combating infection. This is the view of the majority of surgeons at the present time as far as the cases of traumatic cord paralysis is concerned. There are, however, experienced clinicians (Chipault, Maydl, and others) who consider that early operation is indicated in all cases in which the condition of the vertebral column does not make it probable or certain that the cord has been completely destroyed. The only section of the cord which may regenerate after complete transverse crushes is the cauda equina. This regeneration frequently takes place spontaneously later, so that it is well to wait before operating and not interfere until at least six weeks after the injury. Laminectomy with active tuberculous processes in the spine is not followed by favorable results as a rule, and symptoms of pressure frequently disappear without operative interference. Considering that this fortunate event may take place years afterward, one will be inclined to adopt conservative treatment for a protracted period. Those cases are comparatively more favorable for operation in which the lumen of the vertebral canal is diminished on account of the deformity in healed caries. In these cases improvement can only follow operative widening of the canal.

Primary tumors of the cord are usually located or perhaps only recognized after the appearance of grave cord symptoms. Sometimes a probable diagnosis can be made from the root symptoms or from paralysis of the muscles with atrophy. If it is possible to determine the level of the process, one should operate as early as possible. As a rule the symptoms of pressure disappear after operation upon tumors that develop slowly. This is, however, not always the case, and one should not hazard the chances of success by too long waiting. If it is necessary to keep the patient under observation for some time before interfering, the time should be utilized with antisyphilitic treatment, which is always indicated because a syphilitic process can hardly ever be absolutely excluded. Even when syphilis is present, recovery does not always follow, and it may be necessary to operate.

F. Krause reports 32 cases of tumor of the spinal cord that were operated upon, to which may be added 1 operated upon by Sonnenberg. In 31 of the 33, the tumor was found: 18—*i. e.*, 54.5 per cent.—recovered, or improved sufficiently to walk; 15—*i. e.*, 45.5 per cent.—died. The tumor was not found in one case because it was sought for too low down, and in another case it was not recognized. The mortality is high, but without operation all of the cases would have died sooner or later. The tumors are usually benign, and if recovery takes place it is apt to be permanent.

Neuralgia has recently become an indication for laminectomy. The spinal nerves are divided intravertebrally either within or outside of the dura. In the former case only the posterior root is divided, and in the latter both portions are sacrificed. Resection of the posterior roots was first performed by Abbe, Bennet, and Horsley and has recently been recommended by Chipault. After opening the dura the posterior roots are carefully isolated with forceps and divided close to the cord. The extent of the nerve resected depends upon the length of the intradural course, which is short in the cervical region (1 cm.) and increases from above downward, being about 3 to 4 cm. in the dorsal region. Resection of 1 to 2 cm. will probably always be sufficient, whereas simple division does not guard against recurrence because the roots are liable to reunite just as the peripheral nerves. Care must be taken not to injure the cord itself or the motor roots.

For the purpose of determining whether the proper root is being divided, the motor roots may be irritated with a weak faradic current using sterile electrodes. The muscular twitchings will indicate whether the proper segment is being attacked.

Intradural resection of roots is not without danger. Of the 7 patients first operated upon, 2 died. This step should be reserved as a last resort for very severe cases of neuralgia after all other measures have failed. Chipault claims that the above operation is counterindicated when the neuralgia is associated with muscular spasms. According to his view, the motor portion of the nerves should be resected in these cases, which may be done with much less danger extradurally either inside or outside of the vertebral column. Intradural resection is not indicated with nerves that are purely sensory or when the motor portion is of slight importance. The great value of resection of the posterior roots consists in preserving the motor portion, provided it is important to do so. Furthermore, this operation is the only means of affording relief in neuralgia of the roots, because the radicular arrangement of the neuralgia proves that the trouble is inside of the dura. The success of intradual division of the roots has been immediate even in the cases that died subsequently, because the pain ceased or was diminished greatly. In cases in which recovery was not complete it is fair to presume that the number of roots resected was too few. In a case reported by Abbe extradural division of the nerve had been without success and the pains became less later after an intradural operation, which proves that the methods are not of equal value.

The dangers of intradural division of the roots are those associated with laminectomy in general and the opening of the dura. First of all, the hemorrhage may be very annoying before the column is reached. This may weaken the patient so much that the operation has to be performed at two sittings. Chipault recommends that resection of the roots should always be done at two sittings. This has the disadvantage that it is more difficult to preserve asepsis, and therefore increases the danger to the patient. The danger of infection is especially great with fresh injuries where the crushing of the soft parts forms a *locus minoris resistentiæ.*

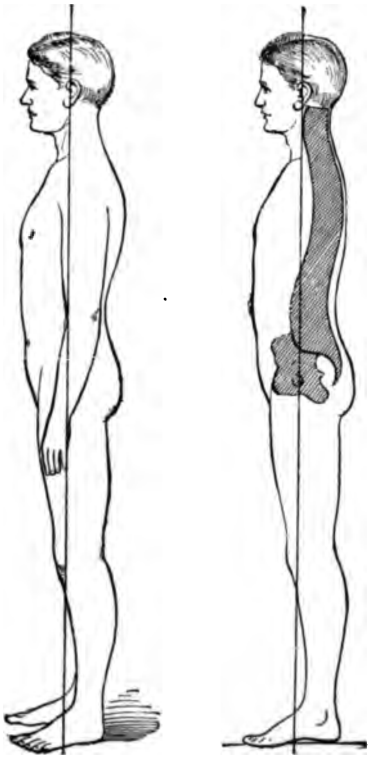
The constant flow of cerebrospinal fluid may saturate the dressings and favor secondary infection. This flow of fluid in itself is not without danger, and has repeatedly been followed by a fatal termination even without infection. Both cases of intradural resection that died were supposed to have succumbed on account of loss of cerebrospinal fluid. At the time of operation one should avoid allowing the fluid to flow out unchecked. The position of the patient should be such that the head is lower than the opening into the column. Post-operate flow should be prevented by exact suturing of the dura and accurate apposition of the edges of the wound. In both of the cases which died the dura was not sutured at all, or only incompletely, and both were drained. The deaths were due to an error in technic, which will be avoided in future and thereby improve the prognosis. The less the danger, the more excusable it would be to operate unsuccessfully once in a while. Exploratory laminectomies should be avoided, and are to be as severely criticized as the corresponding practice in the region of the skull.

As long as it is impossible to separate clinically simple compression of the cord from degeneration and contusions, the lack of certainty in the diagnosis will be associated with a certain percentage of unsuccessful results.

MALFORMATIONS, INJURIES, AND DISEASES OF THE VERTEBRAL COLUMN.

Anatomical and Physiological Remarks.—The most important typical curvatures of the spine that are normal are best seen in median section. The curvature is anterior in the cervical region, posterior in the dorsal region, and anterior in the lumbar region, whereas the sacrum and coccyx have posterior curves. The only one of these curves existing at birth is the dorsal curve, which may even be found in fœtal life. The longitudinal section shows this curve distinctly, whereas in a living child the back appears straight on account of the

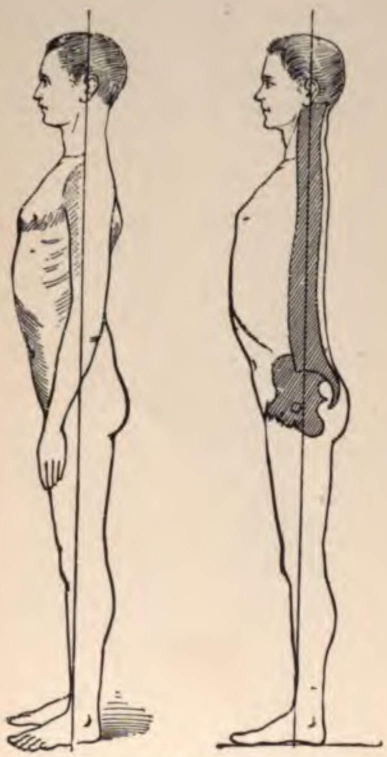
FIG. 237.



Normal back.

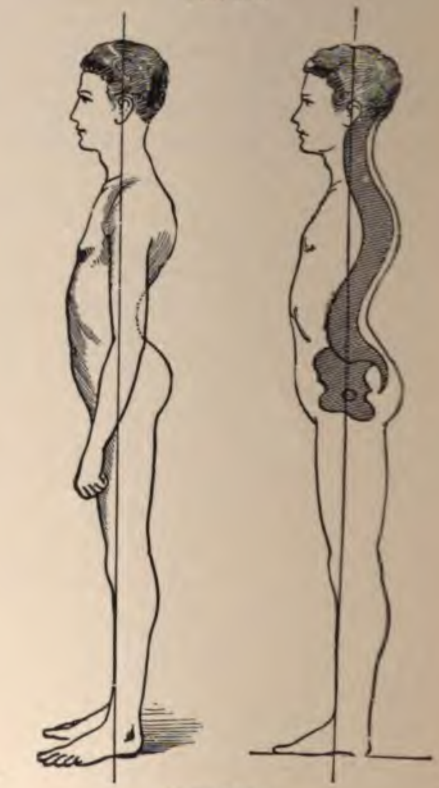
unequal thickness of the soft parts. During the period the infant remains lying down this condition persists. With the first attempts to sit upright the body will be bent forward somewhat. The muscles do not contract and the vertebræ bend until checked by the ligaments. The abdominal contents help to support the weight of the body, and there is a complete posterior curve of the back. The term lordosis is applied to the cervical and lumbar curve, and kyphosis to the dorsal curve. The cervical and dorsal lordosis are compensatory curves and serve the purpose of correcting the disadvantage of the complete dorsal kyphosis in the infant. At first the extensors of the neck pull the head backward and produce the cervical curve which is sufficient for sitting with the legs straight forward. On standing the centre of gravity is placed farther backward. A child, learning to walk, over-extends the lumbar vertebræ because the simple upright position is not sufficient compensation for the dorsal kyphosis. The lumbar lordosis serves the purpose of maintaining the equilibrium and belongs to the static curves. The muscles, ligaments, and bones gradually become accus-

Fig. 238.



Flat back.

Fig. 239.



Hollow back.

tomed to the new position. The vertebræ assume an average position which becomes more or less fixed about the sixth or seventh year. Up to that time the curves of the back disappear on lying down. (Hoffa.) These curves may vary considerably as regards their degree without being pathological. A slight dorsal kyphosis is associated with slight compensatory curves. The accompanying diagrams indicate the chief types of standing: Fig. 238 represents a flat back, Fig. 239 a hollow back, and Fig. 237 the average. The weight is borne in a line passing from about the middle of the vertex behind the angle of the jaw through the hip-joint and reaches the ground at Chopart's joint. If the extensors become somewhat tired, the curve may be increased; for instance, the dorsal kyphosis. This is especially the case when sitting, because it is not difficult to displace the centre of gravity forward. On standing, the position of the pelvis and lower extremities compensates for the dorsal increase. Lorenz has proved that the so-called physiological scoliosis is only apparent.

CHAPTER XXIV.

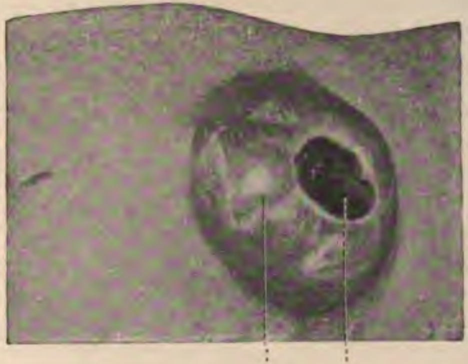
MALFORMATIONS OF THE VERTEBRAL COLUMN.

SPINA BIFIDA.

THE central nervous system consists of a medullary canal the edges of which gradually become approximated. They finally become united and separate from the neighboring epidermis. The lumen of the tube forms a central canal and the ventricles of the brain. The mesoderm surrounding the medullary canal furnishes the membranes and bony structure. The etiology of disturbances of development is unknown. Amniotic bands do not explain all the cases. Complete absence of union is termed rhachischisis. This may involve the entire medullary tube or only individual vertebræ. In the latter case the defect is usually found in the lumbar region. The epidermis remains connected with the medullary tube, although the nerve-elements are destroyed, their place being occupied chiefly by the pia mater. The remnants of the cord may be recognized on the pia as the area medullovasculosa. This consists of a velvet-like strand in the median line covered with fine tabs and of a dark-red to reddish-brown color. Microscopically it is shown to consist of numerous bloodvessels and nerve-elements. This structure is sometimes covered with remnants of epithelium, and is surrounded by the zona epithelioserosa. In this there are no nerve-elements whatever, and the pia would be exposed were it not that the epithelium from the surrounding skin had grown over it. The appearance is that of a fresh scar. The zona epithelioserosa is surrounded by the zona dermatica. This is normal appearing skin, in the connective tissue of which the dura and pia of the vertebral canal become lost. If the lesion is not complete, the zona medullovasculosa will show a dimple at its upper and lower fold, which indicates the entrance to the closed portion of the central canal above and below. With this deformity the nerves leaving the cord must be sought for on the ventral side of the groove in the region between the pia and arachnoid.

The skin of the back shows a more or less extensive defect which contains pia with remnants of the cord. If a section is made through a region of this sort, the subarachnoid space will be found beneath the pia, beneath this the arachnoid, and deeper still the dura, which lines the vertebral canal. There is an increased quantity of fluid in the subarachnoid space which may possibly be due to inflammation, and may be so abundant that the overlying soft parts—*i. e.*, the pia and remnants of the medulla—are elevated above the level of the surrounding skin. This gives rise to what is familiarly known as myelomeningocele (Fig. 240). The two varieties of fissure described have in common a defect of the skin, thereby exposing tissues that are not

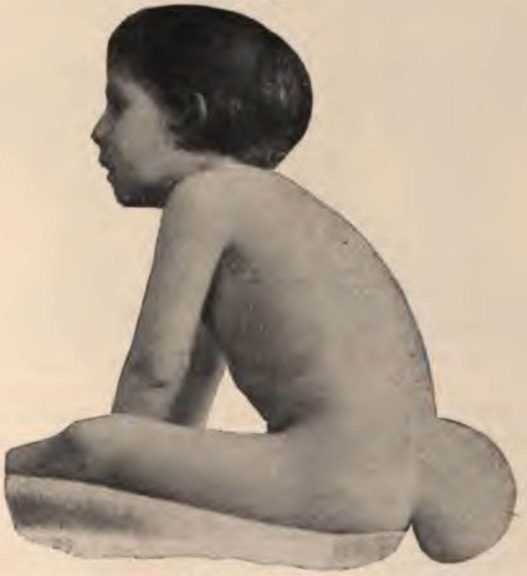
Fig. 240.



Myelomeningocele.

possessed of the necessary power of resistance unless covered with epithelium secondarily. The result is that maceration may take place

Fig. 241.

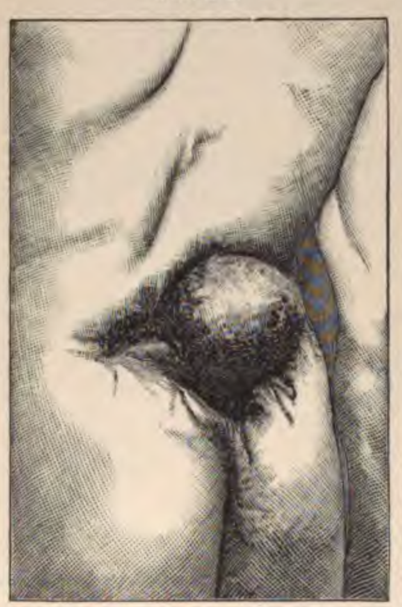


Case of spina bifida. (Park.)

even before birth, and during the first days after birth inflammation of the surrounding tissue always occurs, which extends to the central canal and brain and causes death by producing meningitis. Furthermore there is a lack of development of the cord or secondary destruction of portions already developed, which is evident from the paralysis of the legs, sphincters, etc. These two varieties are frequently associated with other clefts of the skull, abdominal wall, bladder, or intestines, and are rarely found in viable children.

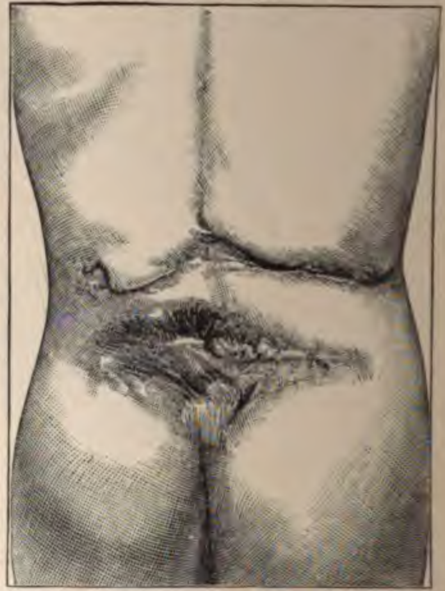
A cleft of the vertebral canal is always associated with a cleft of the epidermis. If the medullary canal closes, the epidermis always unites over this. The external wall always undergoes practically normal development, whereas the changes in the mesoderm may vary. Almost all the malformations that will be considered have in common a cleft of the bony canal. The pia and arachnoid are always closed if the cord has developed to form a canal. The cleft in the bone is usually associated with a similar condition of the dura. Fluid may accumulate in the central canal and produce a tumor of considerable size. The cord itself may be atrophied, especially the dorsal portion, which may be restricted to a zona medullo-vasculosa, just as in the open varieties of spina bifida. The cavity is lined with a layer of cylindrical epithelium, which may, however, leave portions of the thickened pia uncovered. This form of spina bifida, termed myelocystocele, is often covered only by a very thin layer of skin. After dividing this the loose connective tissue of the arachnoid is immediately exposed. The dura never forms any portion of the sac. The skin and sac are frequently closely united, either as the result of inflammatory changes or on account

FIG. 242.



Meningocele. Before operation.

FIG. 243.



Meningocele. Twelve weeks after operation.

of insufficient differentiation of the overlying membrana reuniens. (Wieting.)

In myelocystocele the cleft in the vertebral canal is comparatively narrow and may not be in the median line. Other pathological changes, such as curvatures, absence of vertebræ, and deformed vertebræ, are not uncommon. This variety of spina bifida is also frequently associated with deformities elsewhere. The paralysis is usually not so marked as with complete clefts, because the nerve-tissue is less destroyed. The epidermis which covers this variety of spina bifida is at first a continuous structure, but soon after birth or even before birth circumscribed losses of substance appear which are to be considered decubitus ulcers. They may heal or may become deeper, attack the pia, and perforate the sac. The sac itself being a distended central canal, does not contain nerves. In the various meningoceles where there is an accumulation of water between the membranes of the brain the conditions are different. In these cases, according to Hildebrand and Muscatello, the dura is always defective. The fluid accumulates in the meshes of the arachnoid and distends this so as to form one continuous cavity which is traversed by the nerve-roots. These are not infrequently adherent to the wall of the sac. (Figs. 242 and 243.) Myelocystocele and meningocele may be combined. The meningocele may be situated on the ventral or dorsal surface of the myelocystocele or in both places at the same time. The conditions may be complicated on account of rupture of the myelocyst. In the ventral variety of myelocysto-meningocele and in the dorsoventral variety the ventral accumulation of fluid may lift the cord or the myelocyst out of the vertebral canal and displace the latter backward into the sac. Both varieties, especially the ventral variety, produce much atrophy, especially of the ventral portions of the cord, which is evident from the grave paralysis produced. In rare cases a meningocele may protrude between the two arches of intact vertebræ. The small communication between the vertebral canal and the external sac becomes obliterated and the sac persists independently. In certain cases there may be a cleft of the vertebral canal without protuberance of the contents. In these cases the cleft is usually closed by a membrane and the defect is called spina bifida occulta. In this variety of spina bifida tumors are frequently found, such as lipoma, myoma, fibroma, angioma, dermoids, cholesteatoma, and mixed varieties. These new growths may be either inside or outside of the vertebral canal, within the membranes of the cord, sometimes immediately over the cord itself, or presenting in the bony cleft immediately beneath the skin, and are supposed to be due to misplaced foci of development. When the tumor is found outside of the vertebral cord, it presents as a prominent swelling in the dorsal region; one on the inside of the canal limits the space in the canal, and may produce symptoms indicating this restriction of space. Sometimes it may not be detected provided it has no external portion. If there are protruding portions of the contents of the vertebral canal, these may become strangulated, shrink, and disappear entirely.

Almost all clefts of the vertebræ are associated with an overdevelopment of hair in the surrounding skin. This hypertrichosis is especially pronounced in cases of spina bifida occulta, which may be the only symptom attracting attention. This hair, which during childhood is only 1 to 2 cm. long, may at puberty become 25 to 30 cm. long. The hair is usually so arranged that it forms a crown over the centre of the defect. When well developed, it may resemble a tail. Spina bifida may appear in any region of the spine, but is much more common in the lumbar and sacral regions. The cervical and dorsal regions are next in frequency, and the sacrum itself is least affected. Meningoceles, on the other hand, are much more common in the sacrum, rarely in the cervical or lumbar and dorsal regions. Spina bifida occulta is usually found in the sacral or lumbar regions, rarely in the dorsal region, and has never been observed in the cervical region. There is a cleft of the body of the vertebra which is of no surgical interest, and will therefore not be considered.

Diagnosis.—The seat of the defect, and the fact that it is usually congenital, render it easy to make a diagnosis except in the cases of spina bifida occulta. It may be more difficult to tell which variety of the condition is present in the individual case. The differential diagnosis is not only of great importance as far as the prognosis is concerned, but also on account of the treatment, so that every possible aid for determining the variety should be made use of. The complete clefts and the myelomeningocele (Fig. 240) offer the least difficulty, and are indicated by the defect in the skin. In the former are found the zona epithelioserosa and the area medullovasculosa; in the latter the dimples indicating the closed portion of the central canal with the red or reddish-brown velvet-like surface, which in complete clefts is found in a groove and in myelomeningocele is situated over the convexity of a hemispherical fluctuating tumor with a broad base. This tumor is usually translucent, and the cord itself can be recognized as a dark band over the most prominent portion of the tumor. Paralysis of the legs, of the bladder, and of the intestines, and deformities elsewhere, are common in the two latter varieties.

In cases of spina bifida covered by skin it may be much more difficult to make a differential diagnosis between myelocystocele and meningocele, and combinations of both. They all appear alike. Only in cases of myelocysto-meningocele ventralis will the cord show a distinct shadow over the most prominent portion of the tumor. The degree of fluctuation is about the same in all cases. When pressure on the sac produces swelling of the fontanelles, the tumor is more apt to be a myelocyst because there is a direct connection through the ventricles and central canal.

In cases of pure meningocele paralysis is uncommon. In myelocystocele there is usually atrophy of the dorsal portion of the cord producing marked sensory disturbances. In myelocysto-meningocele anterior there will be found severe motor paralysis, usually combined with sensory disturbances. With a meningocele the local condition will oftentimes be the only characteristic sign, whereas with myelocystocele other deformities are frequently observed. There may be curvatures of the column, abnormal development of the legs, club-feet, etc., although all of these conditions may be absent. The location of the deformity is of importance, because meningocele is almost exclusively limited to the sacrum, whereas myelocysts may be found anywhere. The cleft in the vertebral canal is least and the peduncle of the tumor is smallest in meningocele. The same applies to myelocyst, whereas when both are associated and the cord is displaced backward into the sac and in myelocysto-meningocele ventralis and dorsoventralis, the opening is wide. In the dorsal variety the opening and peduncle are small. The peduncle may be considerably increased as a result of œdema. With simple myelocele and meningocele the bony canal cannot oftentimes be felt. Hemorrhages into the overlying skin are common in myelocyst and extremely uncommon with meningocele. The condition of the overlying skin found in myelocyst and meningocele may differ on account of secondary changes due to ulceration, so that its differential diagnostic value is lost.

The diagnosis may be extremely difficult with spina bifida occulta. The marked overgrowth of hair not infrequently is the only outward sign of deformity. Cicatricial changes of the overlying skin are not uncommon, and, according to Muscatello, are always present with heterogeneous growths in the vertebral canal. The defect in the bone may usually be felt, although not always, especially in cases in which the tumor protrudes and covers it up.

Abnormal curvatures of the spine, deformities, especially pes equinovarus, signs of pressure upon the cord, or evidence of degeneration, especially in the posterior portion, are conditions frequently found with spina bifida occulta. Sensory and trophic disturbances, frequently leading to extensive neuroparalytic ulcerations, may follow the faulty condition in the cord and be of differential diagnostic importance. After the sac has been opened, the presence of nerve-trunks in a cavity lined with a shining membrane will indicate that one has opened a meningeal sac. The absence of nerves and a grayish-brown lining with a whitish network here and there will indicate that a myelocyst has been opened. These incisions are preliminary steps to radical interference.

Prognosis.—The prognosis of spina bifida varies with the variety. It is absolutely unfavorable when the central canal remains open, as in rhachischisis and myelomeningocele, partly on account of the deformities in other organs, partly because of the infection that takes place in the open medullary canal. Purulent meningitis usually follows, which cannot be controlled by any form of treatment. In cases of spina bifida that are primarily closed meningitis usually follows perforation of the sac. This accident is usually due to ulcerative processes, or because the skin becomes gradually thinner and thinner on account of the increase in the quantity of fluid contained. When a sac of this sort is freely connected with the ventricles of the brain, sudden rupture is apt to be followed by immediate death. Even when the opening in the sac heals, the tumor may reform and burst again. In very rare cases spontaneous recovery takes place in this way. (Knox.) This condition may be present in utero, as shown by Bärensprung, Cruveilhier, Braune, and Czerny.

The paralysis that persists is a further source of danger to the children, especially when it involves the bladder, because the deformity is almost sure to result fatally sooner or later in these cases.

Even with the primarily closed variety of spina bifida the prognosis is very unfavorable. The conditions are more favorable with simple meningocele, because they are frequently isolated, not associated with other deformities, and paralysis is uncommon. They are exposed, however, to the dangers of perforation, just as the other types of this disease. Most all of the cases in which the patients have lived for some time with spina bifida belong to this group, while myelocystoceles are probably not so favorable in this respect, although the prognosis is the next most favorable.

Broca reports a case twenty-three years of age and one forty-three years of age. Delacour operated upon one case eighteen years of age, Whitehead operated upon an adult, and Robson operated upon an individual thirty-five years of age. In Breslau a man twenty-four years of age, perfectly healthy except for slight atrophy of the right leg, was operated upon successfully for meningocele. Wieting has recently reported 2 cases twenty-two years of age which developed club-feet in the course of time. Most of the cases die early. Of 647 cases that died in 1882 in England, 615 were under one year of age. Of 90 cases not operated upon, the vast majority died within the first few weeks. Only 20 reached more than five years of age. (Wernitz.)

Treatment.—Radical operation is indicated in all cases in which energetic treatment is necessary, although occasionally one will be obliged to resort to the older less radical procedures. In cases with very little prominence of the sac one may endeavor to prevent any increase in the size of the hernia by using a soft pad. One should always remember, however, that the thin overlying skin is very liable to ulcerate, and that an ulcer in this situation is of grave significance, because perforation of the sac may be followed by death or at least make an aseptic operation impossible. Only cases that project very slightly and that are covered with normal, well-nourished skin are adapted to this sort of treatment. This pad may be made of gauze and fastened to the body by means of a piece of adhesive plaster. In this way it will be determined whether the pressure of the pad is well borne. If this is the case, a metal pad lined with some soft material may be fastened around the body by means of straps.

Aspiration of the sac is a palliative measure because it removes the pressure and lessens the danger of rupture when for some reason or other a radical operation is counterindicated. The danger of this method consists in lowering the pressure too rapidly, which may be followed by sudden death, as in König's case. The child was set up and all the cerebrospinal fluid poured into the empty sac. The patients, according to Leyden, should always be kept lying down during aspiration and for some time afterward. There is also danger that the puncture-wound may not heal, and that the cerebrospinal fluid may continue to leak and moisten the bandages, which become infected and are thus the cause of meningitis. This danger is best avoided by choosing the base of the mass for aspiration, and not the region of the sac, which is covered only by a very thin layer of skin. The needle used should be as small as possible, and be introduced diagonally, not vertically, so that the canal is comparatively long, and may be compressed from without or by increased pressure within the sac, just as in the case of the ureter by a filled bladder.

The result of aspiration, aside from very few exceptions, is always negative. Aspiration has been combined with injections of iodine that are supposed to set up sufficient inflammation to produce a cure. The direct action of irritating fluids upon the central nervous system does not seem to be especially dangerous, as shown by Brainard, Tournesco, v. Ranke, and others, who have treated hydrocephalus with iodine without disastrous results. Brainard treated a series of cases of spina bifida with iodine, and noted improvement in some and permanent cure in others. v. Langenbeck, v. Esmarch, and Hennemann have obtained good results with this method. Morton's solution of iodine and glycerin is said to be less irritating and equally efficient. Morton removed a few cubic centimetres of cerebrospinal fluid and injected 2 to 7.5 c.c. of a solution consisting of 1 part of iodine, 2 parts of potassium iodide, and 50 parts of glycerin, through a lateral puncture. Sometimes it was necessary to repeat the injection, although a third injection was rarely indicated. Morton reports 80 per cent. of cures and 20 per cent. of deaths. The Clinical Society of London reports out of 71 cases, 35 cures (49 per cent.), 4 improved (5.4 per cent.), 5 not improved (7 per cent.), and 27 deaths (38 per cent.). Aspiration itself was the cause of death 30 times in 46 cases. Similar experiments have been made with alcohol, potassium iodide solutions, etc. The results of the injection treatment are not ideal, but the method may be resorted to when a radical operation is counterindicated.

Strangulation of the sac is much more dangerous than injections and should be condemned. This method was recommended by Bell in 1791, and has since been made use of by Trowbridge, Polaillon, and Rizzoli. An elastic band is placed around the sac and prevented from slipping by passing two needles through the sac at right angles to each other, or by means of a clamp. Before applying the elastic ligature the sac may be aspirated, and after ligation it may be cut away or left to separate off. Although this method has been successful repeatedly, it is to be condemned, because one never knows whether nervous tissue is being destroyed or not.

Radical operation is without doubt the most sensible metho
treatment. One should always recognize the contents of the sac,
any nerve-tissue that is capable of function should be preserved.
operation is as follows: The skin-incision should be made of suffi
size and made in such a way as to furnish sufficient flap to a
the wound to close by first intention. The peduncle should be
sected out, the sac opened, and the contents examined. Nerve-ti
that may be adherent should be dissected off and dropped back.
sufficient quantity of the sac should be resected, the edges s
together, and then covered with skin.

The surface of a spina bifida is frequently covered with a lay
skin so thin that it is not adapted for covering in the defect. In t
cases it is well to make a skin-flap from the neighboring reg
Every effort should be made to have the wound heal by first inten
and prevent leakage of cerebrospinal fluid. This trickling of 1
is dangerous, because there is a direct communication between
skin and the meningeal sac which favors infection. The cha
of secondary infection are greatly increased on account of
constant moistening of the dressing. It is dangerous to drain
wound and quite unnecessary, provided one's technic is sufficie
aseptic, and when cases are not operated upon which cannot be c
aseptically.

Robson's point that the suture-line of the meninges and that of
skin should not lie immediately one above the other, is well taken.
when flaps are made this state of affairs is easily avoided. In Bre
the author prefers to suture the meninges longitudinally and close
skin transversely. The areas left uncovered in making a flap should
closed immediately, and when this is not possible may be grafted a
Thiersch's method.

C[illegible] the bony defect w
more resist[illegible] recurrence of a her
[illegible] and the
[illegible]
[illegible] skin. O
[illegible] operati
[illegible]

nerves that are exposed should be replaced. If adherent to the cyst-wall, they should be dissected out if possible. If one has to deal with a fine network of nerve-fibres, it may be best to sacrifice them or to resect the portion of the cyst-wall to which they are adherent and leave the tissue behind. Not infrequently the nerves involved are of no importance, although this cannot always be determined at the time of operation, so that it is best never to sacrifice nerves unless obliged to do so.

In myelocystocele the conditions are somewhat more difficult, and some authors question the justifiability of operation, because in this condition a portion of the sac-wall is made up of the dorsal part of the cord, which at the time of operation must be sacrificed. In cases in which there is but little bulging it may be possible to dissect the skin from the meninges, empty the sac, and cover the defect with skin or with muscle and skin. If there is considerable bulging, the skin and the corresponding portion of the cord are so thin and so closely adherent to each other that they cannot be separated. In these cases, however, the section of the cord under consideration is absolutely of no value, because when removed it does not increase the evidence of paralysis. When it is not possible to save any of the nerve constituents, one will hesitate less about removing the sac *in toto*.

Of the combinations of the above varieties of spina bifida, myelocysto-meningocele dorsalis is of greatest interest surgically. In the ventral variety associated with severe paralysis operation is useless. The ventral portion of the cord has become completely disintegrated and the dorsal portion is damaged. In favorable cases it may be possible to prolong life, although the limits in this direction are meagre. If an operation is contemplated, the following steps are indicated: emptying of the meningocele, diminution in the size of the myelocyst to a degree that allows of reposition, besides covering with skin or with muscle and skin.

The conditions are very much alike in myelocysto-meningocele anteroposterior. There exist similar objections to operation, which in itself is somewhat easier, because the dorsal meningocele obviates the tiresome dissection of the posterior myelocyst-wall from the overlying skin.

Myelocysto-meningocele posterior differs from simple myelocystocele in this latter point, and, next to meningocele, it is the most favorable condition for operative interference. If the myelocyst is small, it may be left intact; if it is large, it should be treated according to the rules laid down for myelocysts.

The cases of spina bifida in which the cord is exposed are not operable.

Rhachischisis has been operated upon only once, and then with but temporary success. (Koch.) Bayer has operated repeatedly for myelomeningocele. This author made an incision around the zona epithelioserosa and buried this portion with the nerves and covered the whole by a muscle-skin plastic. Muscatello considers that the impossibility of operating aseptically is a counterindication to this interference. The exposed cord is already infected at the time of birth, and during the first days of life extensive suppuration may have developed. Disinfection before operation with weak antiseptics is of no use, and when drugs of sufficient strength are used, the cord, the vitality of which is but slight at best, is destroyed. If suppuration continues in the buried area medullovasculosa, it will extend and lead to meningitis, as in the case of several children operated upon by Bayer. Even if infection is avoided, the surgeon should consider the kind of life that he is preserving. The tracts and ganglion-cells in the diseased portion have become destroyed. They cannot be restored by operation. On the contrary, still further damage is likely to be done, and scar-tissue will destroy any remaining portion. Paralysis of the legs, bladder, and intestines will persist; and even if the children do not die as a result of the operation or from meningitis, they succumb within a short time.

The amount of paralysis present is the chief indication which justifies operative interference. When there is severe paralysis, perhaps complete paraplegia, one should never operate. The condition of other organs should also be considered. If there are present severe irreparable malformations elsewhere or hydrocephalus, surgical interference is not justifiable.

Ulcerative processes in the region are temporary counterindications to operation, for asepsis may be impossible. In cases of this sort one should first endeavor to heal the ulcers and operate secondarily. Small ulcerations may perhaps be treated in such a way that they do not interfere, which may be especially desirable when it is necessary for some reason or other to operate immediately. The chances of infection are, of course, much greater than when the skin is intact.

Asepsis must receive especial attention in the after-treatment on account of the proximity of the anus. The patients should be kept in a horizontal position, if possible with the head downward, so as to diminish the pressure on the meningeal sutures. This position should be maintained at the time of operation as well. Children should be kept face downward, but adults may be allowed to lie on the side. The author has repeatedly made use of a plaster-of-Paris cast of the anterior surface of the body reaching from the neck to the feet. The hips and knees are partially flexed and the legs separated somewhat. The upper part of the apparatus should rest upon a pillow that supports the head while the lower portion touches the mattress. Children should be strapped to this apparatus, and soiling of the bandage by urine and feces will thus be avoided. The children may be raised for the purpose of drinking, and the sutures may be removed on about the tenth day.

Where an operation is counterindicated, the children should be treated symptomatically. If ulcers prevent operation on a patient otherwise in proper condition, and should there be any danger in waiting, iodide treatment may be carefully tried, although it is safer as a general thing to operate after the ulcers have healed.

When spina bifida occulta produces no symptoms, the condition should be left alone. When there is paralysis, the cases are more favorable when this symptom appear late, so that it is to be presumed that the paralysis is due to gradually increasing pressure. Joues operated upon a patient twenty-two years old who had suffered from paralysis since the seventeenth year. He found some deformity of a vertebral arch with an underlying transverse strand that had pressed upon the cord. A similar case is reported by Maas. In both cases the paralysis improved after operation.

CHAPTER XXV.

INJURIES OF THE VERTEBRAL COLUMN.

THE author will follow Kocher's method of subdividing injuries to the vertebral column with only a few practical modifications :

Partial Injuries :

1. Distortion and
2. Single dislocation of the lateral joint.
3. Contusion and
4. Isolated fractures of the vertebral column (pressure-fractures).
5. Isolated fractures of the arches and spinous processes.

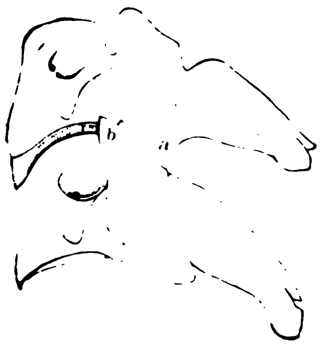
Complete Dislocations with Fracture.

6. Complete dislocations (dislocation of the lateral joints and displacement in the region of the intervertebral disk).
7. Dislocations with fractures due to pressure (dislocation of one or both lateral joints and pressure-fracture of the body).
8. Complete dislocation with fracture, dislocations with diagonal fractures (dislocation of the lateral joints and dislocation in the region of the fractured vertebræ).

INJURIES OF THE VERTEBRÆ.

Distortions and Isolated Dislocation of the Lateral Joints.—These injuries will be best understood if the shape and position of the lateral joints are called to mind. A dislocation is produced by the upper vertebræ sliding downward and forward until the edge *a* (Fig. 244) comes to lie over edge *b*, or slides past this. This means that the posterior margin of the upper articular process comes to rest on the anterior margin of the inferior articular process (Fig. 245) or slides over this in front (Fig. 246). When the upper vertebræ is pushed backward, the articular surfaces are simply separated. This is not possible unless the ligaments become ruptured, which is an extremely rare occurrence. It is relatively more common to have considerable laceration of the capsule in connection with backward displacement, which may be complicated with fracture due to tearing off of pieces of bone. An injury of this sort may be due to some anterior motion if

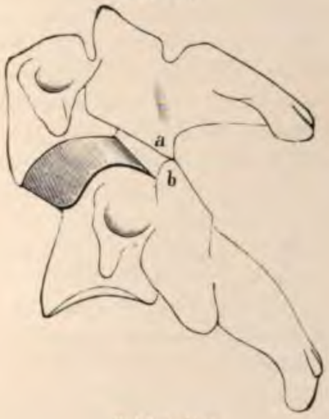
FIG. 244.



Normal position.

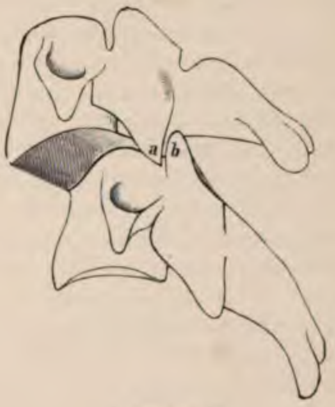
this ceases before the vertebra is dislocated. Distortion and dislocations may be associated with considerable displacement of the vertebræ, and are not found independently in all regions of the column. The cervical region is affected almost exclusively, as it allows of most motion on account of the relative thickness of the intervertebral disks and slight transverse diameter of the vertebræ. In the dorsal region this sort of injury is found only in connection with other damage on account of the attachment to the thorax. Distortions are found occasionally in the lower dorsal and lumbar regions.

FIG. 245.



Subluxation.

FIG. 246.



Luxation.

Distortion of the Vertebral Articulation.—This injury may be produced by a direct blow upon the neck and rarely by muscular action. The most common cause is a fall on the head, which is followed by forced extension or flexion. Forced flexion is associated with anterior displacement of the upper vertebræ and is frequently associated with dislocation. As long as the continuity of the bodies of the vertebræ and their ligaments is preserved, overextension may simply produce distortion. (Kocher.) If extension is associated with torsion, the joint is more affected on the side to which the face is turned. Unilateral distortion results. With flexion and rotation, on the other hand, the opposite joint suffers the greatest amount of damage. Not infrequently the joints of several neighboring vertebræ are affected at the same time. This has been demonstrated experimentally by v. Kryger. According to Kocher, distortion affects most frequently the fourth, fifth, and sixth cervical vertebræ.

Symptoms.—The symptoms of distortion are usually due to pain in the region of the damaged joint. Anything producing motion causes pain, such as passive movements, pressure on the head, pressure on the lateral joints and spinous processes of the vertebræ injured, as well as of the neighboring vertebræ. The patient avoids motion. He keeps his head stiff, and with unilateral injuries holds it in a position which avoids tension on the injured ligaments. The ear is held toward the shoulder of the affected side and the face is turned toward the healthy side.

Sometimes with distortion there are symptoms due to injury of the cord. Although this structure is hardly ever crushed, the forced overextension or flexion may be followed by fatal hæmatomyelia. (Wagner-Stolper.)

Diagnosis.—The diagnosis is made from the excessive pain on motion and the absence of deformity. The seat of pain will locate the injury more accurately.

Treatment.—The treatment of distortion consists in placing the region at rest, which is best done by fixation and extension. The symptoms usually subside within the course of three or four weeks, sometimes sooner. Sometimes tuberculosis develops after injuries of this sort, especially after the slighter varieties, so that these patients should be kept under observation for a considerable time.

Isolated Dislocation of the Lateral Joints.—The mechanism of dislocation has already been considered. The upper vertebra is always spoken of as the dislocated one, so that there is only one isolated anterior dislocation, aside from luxatio capitis, which will be considered separately. The term dislocation will be applied to those cases in which the articular processes are hooked over each other, whereas the term subluxation will be applied to those cases in which there is only partial dislocation. Both varieties may occur on one or both sides.

Bilateral dislocation is usually associated with severe laceration of the structures elsewhere, and will be considered in connection with complete dislocation. Kocher believes that clinically there may be isolated bilateral dislocation, which, however, cannot be supported by anatomical proof. The rare cases of bilateral dislocations without injury to the cord may be considered isolated dislocations. Two cases have been reported by Blasius.

In unilateral dislocation the intervertebral disk may be displaced and partially torn, but with an isolated dislocation it remains intact in so far as it preserves the approximation of the adjoining vertebræ, aided by the anterior and posterior longitudinal ligaments. The posterior ligaments, especially the intercrural ligaments, are very elastic, but are apt to tear and may be completely divided. The injury to the capsule does not resemble the injuries to large joints where the capsule is slit, allowing the head of the bone to pass through, but is more apt to be completely divided transversely, a condition which must favor replacement. Unilateral dislocation is due to an excess of the position assumed by the vertebral column with rotation. When a lower articular process on the right side becomes displaced forward, the head will be turned to the left. Unilateral dislocations have therefore been called rotation dislocation on account of the position. The rotation is not uncomplicated. On account of the downward and backward direction of the articular surfaces the upper vertebra is lifted on the dislocated side, which is associated with abduction—*i. e.*, flexion—toward the healthy side. Finally there must be some flexion, because the column itself cannot lengthen on account of the ligaments connecting the individual vertebræ, and the arches are capable of being considerably separated on account of the elasticity and comparatively slight resistance of the connecting bands. Rotation and abduction are produced only by unilateral dislocation, whereas flexion may be present in bilateral dislocation, and may be uncomplicated by any other position. The diastasis of the neighboring vertebræ during life is evident from the increased distance between the apices of the spinous processes.

In unilateral dislocations the joints on both sides may suffer. The one that is not dislocated may be subject to more or less distortion. The vertical axis of rotation is in the region of the vertebral body, so that the halves of the vertebra must move in opposite directions; for instance, with anterior dislocation to the right the left side of the dislocated (upper) vertebra must move backward, which will be associated with laceration of the capsule. This backward displacement persists until the dislocation has been reduced. Bilateral opposite dislocation, as spoken of by Blasius in cases of this sort, is not correct, because the term dislocation is not applied to simple separation of the joints, especially since it disappears without any especial reduction as soon as the dislocation on the other side is reduced. Abduction and flexion are most pronounced in subluxations when the margins of the articular processes lie one upon the other. Dislocation is completed by having the upper articular processes slide downward over the lower, which diminishes the amount of anterior and lateral deformity, but increases the amount of rotation. The distance between the spinous processes is greatest in subluxations.

Unilateral Dislocations of the Lateral Joints.—These have been termed rotation dislocations, abduction dislocations (König), and flexion dislocations. The former term is most frequently used. The term flexion dislocation should be reserved for bilateral dislocations because flexion is of the greatest importance with this injury.

Etiology.—In rare cases rotation dislocation may be due to direct violence, such as a blow upon the nape of the neck. It is most frequently produced by falling backward on the head, especially if the body rolls over. This injury is found often in individuals, standing on the tail-board of a wagon, who fall on account of sudden starting of the horses. If they do not land squarely upon the back, but reach the ground with the head twisted a little to one side, flexion, abduction, and rotation will be present, which are the necessary etiological factors for rotation dislocation. When they land squarely upon the back, extreme uncomplicated flexion may be followed by bilateral dislocation. Active rotation, due to excessive muscular action, may in rare cases be followed by rotation dislocation. Müller collected 19 cases of this sort, which were produced chiefly by sudden contraction of the sternomastoid. A similar case has been reported by Wagner-Stolper.

Symptoms.—The symptoms of unilateral displacement vary according to whether there is a dislocation or subluxation. In the latter, according to Wagner, the head is bent toward the healthy side on account of the increased length of the vertebral column on the affected side, whereas in dislocations the head is inclined to the affected side. Evidence of rotation, deviation of the spinous process toward the affected side, prominence of the transverse process on the affected side, and of the corresponding half of the body of the vertebra are more pronounced in dislocation than in subluxation. With dislocation of the lower cervical vertebræ, flexion is as a rule compensated for by lordosis of the overlying portion of the vertebral column. Rotation is usually compensated for by rotation in the opposite direction in the atlo-axoid joint. Kocher is of the opinion that flexion takes place always toward the diseased side. His views are based upon his experience and upon the condition found on autopsy.

FIG. 247.

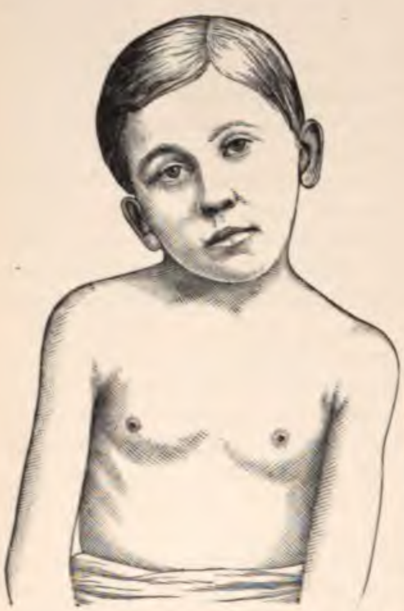
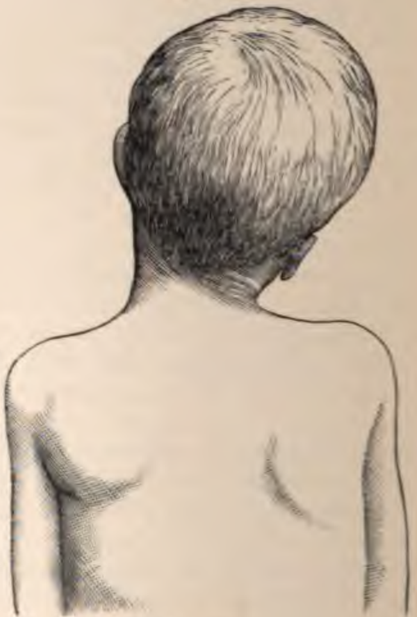


FIG. 248.



Left subluxation of the fifth cervical vertebra.

Diagnosis.—Only a partial diagnosis can be made on inspection. Displacement of the spinous processes should be palpated for, and can only be demonstrated in the lower three cervical vertebræ and in the region of the axis. The other spinous processes are covered by the muscles and the ligamentum nuchæ. The anterior surface of the upper three or four vertebræ may be palpated in the pharynx, and any dislocation of the two or three upper cervical vertebræ may be detected in this region. The transverse processes of the lower cervical vertebræ may sometimes be felt in the neck. These should be sought for along the inner margin of the sternomastoid, but cannot always be found in obese individuals. Displacement of the spinous processes may be detected with the *x*-rays. Transverse plates do not give as much information as anteroposterior ones, but may be of value at times, because the prominence of the body of the vertebræ may become evident.

The pain is generally less in dislocations than with distortion. The muscular traction holds the dislocated articular process against the anterior surface of the lower articular process, which makes a sort of joint that does not favor motion. Not infrequently the subluxated joint on one side is more painful than the dislocated joint on the other. The spinous processes are sensitive to pressure, as well as the region of the dislocated joint, the prominent portion of the body of the vertebra and the transverse processes, and most of all the region of the lateral joint on the other side. Pressure on the top of the head is also painful. Active motion is anxiously avoided, and passive motion is painful if at all possible. It is not possible to diminish rotation by turning the head to the affected side, on account of the hooking over of the articular processes. Motion in this direction is comparatively painless. The amount of rotation may be increased and produces pain on the dislocated as well as on the subluxated side. The tension on the capsule with abduction toward the healthy side is painful, as is any attempt to flex or extend. Abduction toward the affected side is relatively painless.

FIG. 249.

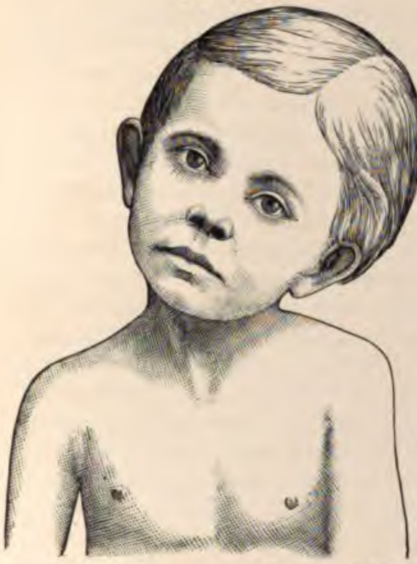
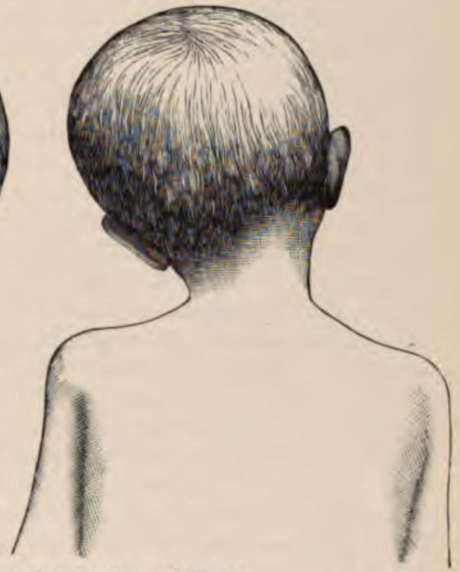


FIG. 250.



Left luxation of fifth cervical vertebra. (Wagner.)

The cord symptoms with rotation dislocation are not usually severe, and may be absent. Severe cases of hæmatomyelia have, however, been observed. Kocher describes 2 cases in which the paralysis appeared later, in one case after one month (redisplacement or hemorrhage), in the other after ten days (redislocation or hemorrhage). Recovery was almost complete in both cases. Radiating pain in the region supplied by the nerves passing between the articular processes is not an uncommon symptom. The nerves on the subluxated side may also be injured.

It should be remembered in the differential diagnosis between dislocation and subluxation that in the latter all movements are possible, although painful. In dislocations certain movements are not possible. An attempt to perform these movements is associated with comparatively little pain.

Treatment.—The treatment of recent dislocation consists in reduction of the deformity under a general anæsthetic, provided there are no counterindications. The anæsthetic serves also the purpose of allowing a more complete examination. The relaxation of the muscles renders reduction much easier and far less liable to damage the cord.

Replacement is easy with subluxation. By abducting the head toward the healthy side—*i. e.*, increasing the already existing lateral flexion—the muscles are stretched that hold the articular processes together. After this has been done a slight amount of rotation toward the diseased side and letting up on the abduction will reduce the deformity. In cases of dislocation Kocher recommends first stretching of the ligaments by increasing the pathological position, at the same time applying considerable slow traction. This should be followed by abduction toward the healthy side and rotation toward the affected side. Rotation should first be made toward the healthy side so as to separate the articular processes one from the other before abduction toward the healthy side lifts the dislocated articular process over the apex of its partner. Wagner believes that the preliminary stretching is unnecessary, and abducts the head immediately toward the healthy side and follows this up by rotation toward the affected side.

Kocher makes use of Glisson's sling for the purpose of extension. Wagner considers that manual traction is sufficient, or, if necessary, towels may be used for a sling. This author places the patient face downward with the head over the edge of the table. The operator then takes the head under his left arm and guides the same, while the right hand and the left partially are free to manipulate the column itself. The movements, especially rotation, in cases of dislocation of the lower cervical vertebræ, must not be done with the head alone, because the upper vertebræ will partake only of the movement. The vertebral column should be grasped above the seat of injury and the head itself made use of for the purpose of extension. Counterextension is made on the shoulders by one or two assistants. This method has the advantage of being applicable anywhere. When the patients cannot be anæsthetized, mechanical extension, which is much more even, is far less painful. If there is only subluxation, manual extension without anæsthesia will be sufficient.

The deformity should be reduced as soon as possible. Replacement is more difficult the longer the period of elapsed time, as in any case of dislocation. It has been successful repeatedly, however, one week after the injury. Wagner replaced 1 case after six, and Richet 1 after eight weeks. The connective-tissue changes and bony adhesions in old dislocations make replacement not only difficult, but even dangerous on account of the liability of injury of the cord. One will favor leaving the dislocation alone as long as the condition of the patient is bearable. Replacement is usually associated with almost complete recovery.

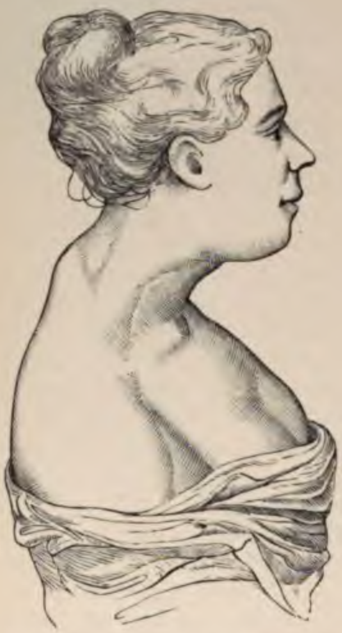
Wagner-Stolper reports 28 cures out of 31 replaced rotation dislocations. Reduction alone does not, of course, complete the treatment. The after-treatment must prevent recurrence of the deformity and provide for absolute rest. Extension as recommended by Kocher has the disadvantage that the patient may relieve himself at least for a time, provided he is not watched constantly. He is more likely to do this because the symptoms are apt to disappear quickly after reduction of the deformity. Collars made of stiff paper or plaster-of-Paris are probably better.

The isolated dislocations between the skull and the atlas and the atlas and the axis present peculiar conditions which will be considered separately. The lateral articulation between the atlas and axis allows of considerable rotation (30 degrees to each side), contrary to the remaining cervical vertebræ. These 30 degrees must be used up before dislocation takes place. The articular processes do not extend much above the arches, so that there is little chance for them to get caught. Rotation dislocation of the atlas therefore is relatively uncommon. Wagner-Stolper reported 3 cases and Kocher 2. Replacement was easy in the 3 cases in which it was tried.

Bilateral dislocation of the atlas is only possible as a complete dislocation with fracture. The ligaments of the odontoid process may be destroyed, or the odontoid process or arch of the atlas may be broken. Dislocations of the skull are of little practical interest. In the case of isolated displacement (Bouisson) reported there was rotation dislocation of the right condyle of the occipital bone backward, produced by direct violence. The patient died immediately.

In bilateral dislocation of the lateral joint, the symptoms of which have already been gone over, there is no rotation and abduction, but flexion is pronounced. This latter symptom is especially prominent in subluxations. (Fig. 251.) When the spinous processes can be felt, there will be found diastasis and displacement of the dislocated vertebra forward. The upper two or three vertebræ can be palpated through the mouth. The prominence of the body or of the transverse processes will be felt in the posterior wall of the pharynx. In the vertebræ situated lower down an attempt may be made to palpate the deformity along the inner margin of the sternomastoid, as already described. The x-rays may be of value in this connection.

FIG. 251.



Bilateral luxation of the fifth cervical vertebra, five months old. (Blasius.)

Dislocation of the vertebral bodies, especially of the lower cervical ones, may produce pressure upon the œsophagus, which is followed by more or less difficulty in swallowing. As a rule bilateral dislocation is associated with fracture or dislocation of the body of the vertebra. The dislocation is reduced after Hüter's method by first replacing one joint and then the other. Wagner-Stolper expresses the opinion that the cord may be injured with this method, especially since with bilateral dislocation its position is already such as to endanger it. They advise traction until the articular processes can ride past each other, and follow this up by slight extension backward with pressure. In cases of subluxation the amount of traction necessary is much less than with dislocations. Wagner-Stolper places the patient on his back with the head over the edge of the table. The shoulders are steadied by an assistant. Great care should be taken not to flex the neck, because the dislocation is increased and the cord is more liable to be injured.

Contusions of the Vertebral Column and Isolated Fractures of the Vertebræ (Contusion Fractures).—Isolated fractures of the bodies of the vertebræ are always pressure-fractures. They are produced by some force acting in the long axis of the spine. Not all the sections of the spine are subjected to this pressure; only those which have a supporting function—*i. e.,* the anterior column of vertebral bodies and intervertebral disks and the double column of articular processes behind. The single column in front and the double column behind may be shortened by any pressure acting in the longitudinal axis of the spine. In the posterior columns the articular processes slide past each other. The amount of shortening possible in this way is not great and soon meets with bony resistance. Fracture of the articular processes and of the arches is not very common on account of the dense consistence of the arch. The anterior column is much more elastic on account of the interposed synchondroses. It is, however, much less resistant because the bodies of the vertebræ, consisting largely of spongy bone, are very apt to collapse and the intervertebral disks may become crushed. Practically the shortening of the column is generally combined with flexion. After the articular columns behind have shortened to their limit, flexion and compression of the vertebral bodies and intervertebral disks follow until the limit of their elasticity is reached, when contusions of the disks or pressure-fractures of the vertebræ result.

Flexion may be produced in various ways. The individual has a tendency to flex his spine while falling. This amount of flexion is increased when he lands on his head or his feet. The normal position of the thoracic column is one of flexion, and this position is simply increased by any force acting in the longitudinal axis. The unequal resistance of the three columns is of importance because in cases of flexion the weakest column gives way first when overtaxed—*i. e.*, the anterior.

The effect of flexion on pressure-fractures varies. It may be so marked that dislocation of the lateral joints is associated with fracture of the body. The mechanism is practically the same as with isolated dislocation.

Contusions of the bodies of the vertebræ with fissures may be considered theoretically a preliminary stage of complete fractures, although practically they cannot be demonstrated or distinguished from true fractures. As a rule the entire column is subjected to the force, although the fracture is of one or a few vertebræ situated close to each other. This is explained by the fact that the elasticity of the vertebral column and the predisposition to pressure-fracture vary in different regions of the spine.

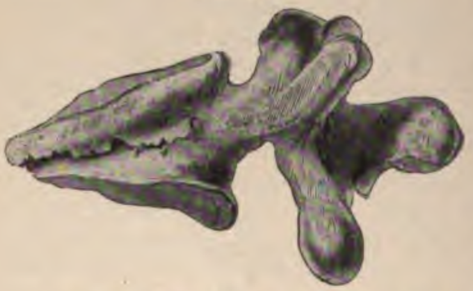
The thickness of the vertebral bodies increases from above downward. The disks are thinnest in the dorsal region, corresponding to the slight amount of mobility in this section. The intervertebral disks are thickest in the lumbar region, corresponding to the large vertical diameter of the vertebral bodies in this region. The relative thickness of the disks is greatest in the cervical region, and the horizontal diameter of the bodies and disks increases from above downward.

The flexibility of the column is greatest in the cervical region, and pressure-fractures are rare here. They are, on the other hand, extremely common in the dorsal region and upper lumbar region. All sections of the dorsal column are not equally liable to fracture. The last two or three dorsal vertebræ and the first lumbar vertebræ are the seat of election. The upper third of the dorsal column and lower lumbar region are much more rarely affected. Kocher found that of 23 isolated fractures of the bodies, the eighth to the twelfth dorsal vertebræ were affected 11 times; the lumbar column, 7 times; the twelfth and first lumbar vertebræ were affected 5 times each. Four of the 23 fractures were in the upper third of the dorsal region. The old explanation that fractures are more likely to occur where a flexible portion of the column joins with the rigid section (Malgaigne) has been discarded. Kocher has called attention to the fact that in the region where fractures are most common the spine has little power of flexion.

Single contusions of the intervertebral disks are uncommon, and have only been found occasionally on autopsy. When the above-described mechanism is applied, the intervertebral disks become crushed between the vertebral bodies. If the amount of pressure exceeds a certain limit, the peripheral solid substance of the disk ruptures on account of the pressure brought to bear upon the central portion, which is almost liquid.

A slight posterior deformity with prominence of the spinous process belonging to the vertebra immediately above, swelling, local pain on pressure and motion, or on any sudden application of weight, such as pressure upon the head or shoulders, are significant symptoms. Recovery takes place by synostosis of the two adjoining vertebræ, and the symptoms do not disappear until this process is complete. During life it will hardly ever be possible to distinguish this condition from pressure-fractures, and one will be obliged to treat the case as a fracture. Pressure-fractures of the bodies of the vertebræ are much more common. The anterior region of the body with forced flexion becomes subjected to an increased amount of pressure which exceeds that brought to bear upon the posterior portion. (Fig. 252.) The body of the vertebra is changed by the force to a wedge-shaped mass. The continuity of the individual vertebra may be preserved. The crushed bony section becomes more dense and the vertical diameter of the body is diminished, whereas the horizontal diameter is increased (pressure-fractures in the strict sense of the word, Middledorpf). In other cases there may be true fragments, which are arranged in a more or less typical way. Several fragments may be broken out of the upper anterior edge of the body (anterior wedge fragments, Fig. 253). This is produced by the upward pressure of the anterior lower margin of the compressing vertebræ. The upper vertebral body exerts a pressure from above downward and backward so that one or more fragments of the crushed vertebra may be crushed out backward into the vertebral canal (posterior wedged fragment). If the amount of displacement is great, the posterior longitudinal ligament becomes torn, or lifted off, which is more common. Fig. 254 represents an anterior and a posterior wedge fracture without solution of continuity. This individual suffered from osteoporosis. If the bending is not pure flexion, but is combined with a certain amount of abduction, one-half of the vertebral body may be crushed to a greater extent than the other.

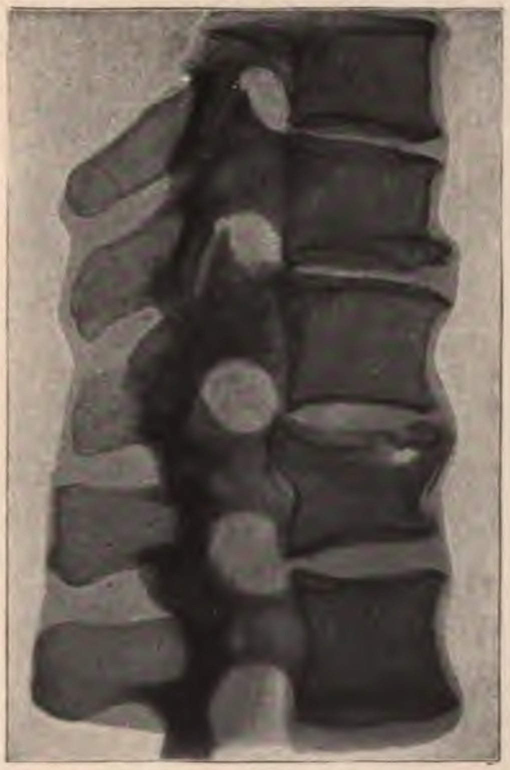
FIG. 252.



Old compression fracture of lumbar vertebra.

Etiology.—The force necessary for the production of a fracture is usually supplied by a fall upon the head or neck or on the sacrum or feet. In the former cases the cervical and upper dorsal vertebræ are more apt to be damaged. In the latter cases the lower section is more liable to suffer. This fact has been demonstrated clinically and experimentally. (Bonnet.) The amount of force applied or the height of the fall need not be especially great, and it is to be presumed that the individual is surprised and not able to assume a position sufficiently quickly to break the force of a comparatively slight fall. Pressure-fractures are observed much more commonly in men, usually in the prime of life, when they are most exposed. Women are rarely affected, and the condition has not been reported in children under sixteen years of age.

FIG. 253.

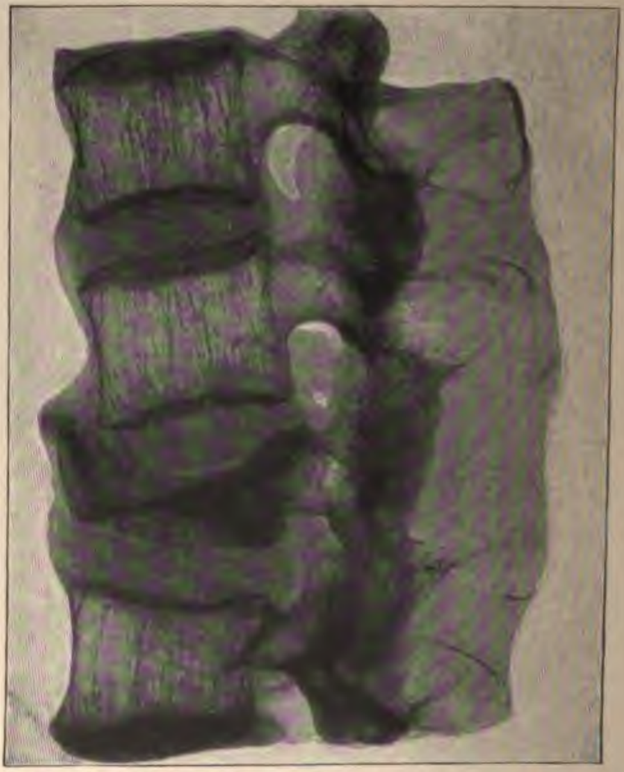


Fresh compression fracture of body of first lumbar vertebra, with separation of wedge-shaped fragment in front. (Breslau Institute.)

Symptoms.—The chief symptom of pressure-fracture is a circumscribed anteroposterior deformity. The greater the amount of damage done, the more pronounced the prominence of the spinous processes, but in slight cases the condition may be overlooked entirely. The angular deformity may disappear spontaneously with fresh fractures the moment the overlying weight is removed—*i. e.*, when the individual lies down. It may reappear again immediately, however, on standing up or sitting. This anteroposterior deformity is overlooked very easily in regions where the vertebral column is normally concave posteriorly. In these regions the concavity must be overcome before an anteroposterior deformity is produced.

A kyphosis develops in cases of fracture even without the aid of flexion when the lateral joints resume their normal position after cessation of the pressure, whereas the vertical diameter remains permanently

FIG. 254.



Wedge-shaped crush of a fourth lumbar vertebra in general osteoporosis. (Anterior and posterior wedge.) (Breslau Institute.)

diminished. The axis of the deformity passes through the lateral joints, so that the arches and tranverse processes behind this are separated. The body of the vertebræ immediately above the injured one sinks downward until it reaches the necessary bony support. The corresponding spinous process is elevated, becomes prominent, and forms the apex of the kyphosis. When several vertebræ are destroyed, no individual spinous process is especially prominent, and the kyphosis is more round.

In the early stages the deformity can usually be obliterated by traction. Later the ligaments become adapted as well as the muscles, callus forms, and when the intervertebral disks are destroyed, synostosis of the affected vertebræ takes place, so that the kyphosis becomes fixed. This traumatic ankylosis is permanent when bony. Even when fibrous the fixation may be such that the movements of this section of the column are so slight that they can hardly be detected.

The changes in the weight-bearing relations secondary to deformity are somewhat compensated for by lordosis of the neighboring sections of the spine. This compensation may be insufficient because on account of the sudden deformity there was no time for the vertebræ to adjust themselves to the new position, and because the solid vertebræ of vigorous males have little tendency to undergo compensatory changes.

When the pressure was brought to bear more on one side than on another the deformity will show a certain amount of lateral displacement. Scoliosis and kyphosis are not infrequently present at the same time. Compensatory scoliosis develops in the neighboring region of the spine, but is subject to the same limitation as compensatory kyphosis.

At the moment of injury the patient usually has a localized sense of pain. In slight cases which are discovered later on account of the secondary signs, the pain may be so slight that the injured individual is able to walk about. Ordinarily, however, he is unable to stand or sit up, or can do so only with considerable pain on account of the superimposed weight. Pressure on the head and shoulders increases the pain. The seat of injury is usually indicated by a spinous process being sensitive to pressure.

The symptoms may be so slight, especially when there are other injuries that attract more attention and necessitate prolonged rest in bed, that they may be completely overlooked. The presence of a fracture will become evident in these cases on the first attempt of the patient to sit up. When the type of injury leads one to suspect that the spine may have been damaged, one should never neglect to investigate carefully.

The presence of a fracture of the sternum should always lead one to suspect some injury of the vertebral column. Fractures between the manubrium and body of the sternum at the level of the second costal cartilage, less frequently of the manubrium itself, and rarely of the body, accompany fractures of the vertebræ so frequently that it is fair to presume that there is some connection between these lesions. The violent flexion combined with the forcing down of the chin on to the breast bone probably produces the fracture.

The nerve and cord symptoms manifest themselves as root pains due to pressure upon the nerves within the constricted intervertebral foramina. Symptoms due to injury of the cord, which may be completely absent now and then, are produced in various ways. The most severe irreparable changes are produced by a posterior wedge fragment which becomes dislocated into the canal and is associated with more or less extensive contusion of the cord. The entire transverse section or only portions may be affected, and in rare cases the picture may be that of a unilateral lesion. The abnormal flexion at the time of fracture may produce hæmatomyelia. It is an important fact that the amount of dislocation is generally greatest at the moment of trauma, and that it may be largely reduced when the force applied is removed. In cases of this sort the autopsy may show a complete transverse lesion of the cord with an approximately normal vertebral canal. When the treatment is not carried out in cases of fracture for a sufficient length of time, cord symptoms may develop. If the spine is allowed to support weight at too early a date, the dislocation may be reproduced. The same symptoms may be secondary to pressure from callus or to inflammatory changes in the membranes of the cord. Callus is especially apt to produce symptoms by diminishing the lumen of the canal, because the fracture always heals purely by periosteal bone formation. The destroyed spongy portion may be considerably absorbed. The spongy portion is especially liable to be destroyed when early bearing of weight is added to the damage produced by the primary injury.

Contusions of one or more synchondroses taking place at the time of fracture heal in the same way as isolated contusions, by synostosis of neighboring vertebræ. In this way several vertebræ may become united by bony union. Kocher presents several specimens of this sort.

Treatment.—The chief point in treatment is to remove for a considerable length of time any weight from the column. This may be done by traction when the fracture is high up. When the lesion is lower down, traction places the parts at rest, which may even be indicated on account of the pain alone. Lying flat on the back removes the superincumbent weight. This may be still further aided by placing pillows beneath the back or placing the patient on a Rauchfuss swing, which tends to overextend the kyphosis. Reference will be made later to the methods used. The patient should not be allowed to leave the bed for four to six weeks.

Traction and overextension not only remove weight, but also tend to replace the fragments. By placing under tension the ligaments whose continuity is preserved the dislocated pieces of bone may be pushed back into place. The posterior longitudinal ligament when intact is of especial importance in this connection because it may aid in replacing the posterior fragments that endanger the cord. The longitudinal dislocation is also overcome by these methods, although only temporarily as a rule. The fractured vertebra has not only been subdivided into fragments, which may unite within a few weeks, but it has also become too low on account of compression. Extension cannot remove this change in shape. The deformity of the column—*i. e.*, the kyphosis—remains permanent, or reappears as soon as the patient attempts to sit up. Supporting apparatus is not able to prevent this symptom, which accompanies almost all fractures due to compression, unless they are made so extensive and heavy that they are extremely inconvenient and can be worn by the patient only for a short while at a time. The moment they are removed the deformity reappears. It should not be concluded from these statements that the removal of weight, long-continued rest in bed, traction, and finally supporting apparatus, at least in the slighter cases, are useless. Aside from a few secondary conditions developing especially in those not appropriately treated, as well as from the fact that rest, especially in the early stages, cannot be avoided on account of the pain, this form of treatment has the important task of preventing any increase in the dislocation of the injured vertebræ.

It is questionable whether ligation of the spinous processes or of the vertebral arches, as recommended by Chipault, is capable of permanently preventing dislocation. The principle of this treatment is as follows: The spinous processes are prevented from separating, which is supposed secondarily to prevent the bodies of the vertebræ from becoming approximated or sinking in. Permanent extension is produced in this way. Chipault exposes the spinous processes in question, perforates them transversely, passes wire through the holes, and connects the adjoining vertebræ. The arches may be joined in the same way, and, if needs be, the transverse processes. Nothing new is to be added to what has been said regarding the treatment of injuries of the cord. The probability of spontaneous reduction or reduction following traction, and the irreparability of changes in the cord itself, make an early operation useless. The disturbances due to too early bearing of weight almost always disappear with appropriate treatment. Overgrowth of callus, on the other hand, when pressing upon the cord, as well as cicatricial contractions, may be greatly aided by surgical interference. The symptoms produced by these processes correspond to those of extradural tumors. The technic of the operation has been described in connection with laminectomy.

Traumatic Spondylitis.—It is generally accepted that true fractures may be the primary cause of this disease. The initial trauma is often very slight, and it must be presumed therefore that fractures may follow very insignificant injuries and produce very slight symptoms. It is questionable whether the term spondylitis is appropriate. The affection has many things in common with local osteomalacia. This condition, however, is considered by v. Recklinghausen to be an inflammatory process, so that the traumatic conditions of the vertebræ may be inflammatory in nature. The term spondylomalacia traumatica would be perhaps more appropriate. The condition was first described by Schede, and later by Kümmell.

Symptoms.—The individual suffers at first from some injury of the spine, such as might be considered in the etiology of compression fracture. Sometimes the injury may be so severe that there is no doubt as to the existence of the fracture, while in other cases the mishap may be so slight as to produce only insignificant symptoms that subside within a few days. The stage of injury with its corresponding symptoms is now passed. In the second stage, which may last for a varying length of time (in one of Kümmell's cases one and a half years), the individual may feel absolutely well. This interval free from symptoms is followed by the stages of spondylitis traumatica proper. Pain reappears in the injured portion of the column, neuralgia of the intercostal nerves with cord symptoms of varying degree is present, and a kyphosis develops which is sharp when only one vertebra is involved and round when the condition affects several. This prominent portion of the spine is sensitive to direct pressure or to pressure in the long axis of the column. Suspension removes the kyphosis, whereas the local prominence of the spinous process persists.

The first stage is short when the original trauma is slight, and long when the injury is extensive. In the latter case it is prolonged at the expense of the interval free from symptoms, and may even be followed directly by the stage of spondylitis. Progressive softening of the vertebræ affected by the trauma is characteristic of this condition, and leads to changes in the shape of the spine associated with extreme pain in the region of the diseased vertebræ. Nerve symptoms are always present. The assumption that the clinical picture is due simply to fracture and the destruction produced by this, does not explain the long intervals free from symptoms during which the patient may forget the original trauma, so that the surgeon is forced to conclude that spondylomalacia has developed in some way or other following the injury. Knowledge of this form of disease is of practical importance because many of the patients carry accident insurance and are unjustly considered malingerers. On the other hand, it may be extremely difficult or impossible at the first examination to say whether the deformity is due to fracture, and that the pain, etc., is simulated, although it is well known that the condition may not produce any disturbing symptoms whatever; or whether the patient is really suffering from spondylitis. The presence of nerve symptoms and the course of the process, combined with measures which enable one to distinguish between actual and simulated pains, will enable a correct diagnosis. The pain, for instance, is not always referred to the same spot, because the patient forgets when his attention is distracted.

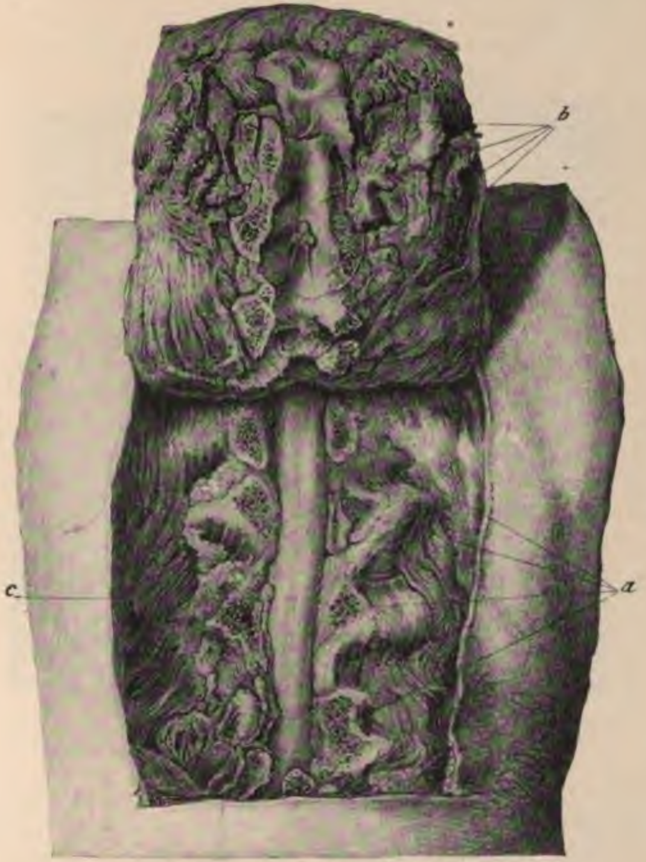
Diagnosis.—It may be very difficult to distinguish the traumatic from the tuberculous conditions of the spine, especially when it is taken into consideration that the latter processes frequently follow some slight injury. The absence of specific tuberculous processes, such as abscesses and tuberculous lesions in other organs, the degree and extent of the tenderness, which in tuberculous conditions seem to be less than in spondylitis, may also be of importance in the differential diagnosis.

Prognosis.—The prognosis is doubtful. In some cases consolidation takes place, the pain disappears, and the column is again able to support weight. In other cases the spine seems to lose its supporting power permanently and the patients are unable to sit upright without the aid of a corset. Patients of this sort are unable to support themselves.

Treatment.—The treatment is prophylactic. Whenever it is reasonably certain that an individual is suffering from a fracture due to compression, the treatment should be prolonged and thorough, even when the individual objects and feels comparatively well. When spondylitis has developed, rest in bed, traction, supporting apparatus, and possibly gentle massage may be indicated.

Results of Fractures due to Compression.—Contrary to the fractures of the bodies of vertebræ complicated with dislocation and destruction of the cord, isolated fractures due to compression are a favorable field for surgical interference. Complete recovery follows only in exceptional cases, for conditions usually remain that are of importance from the accident insurance standpoint.

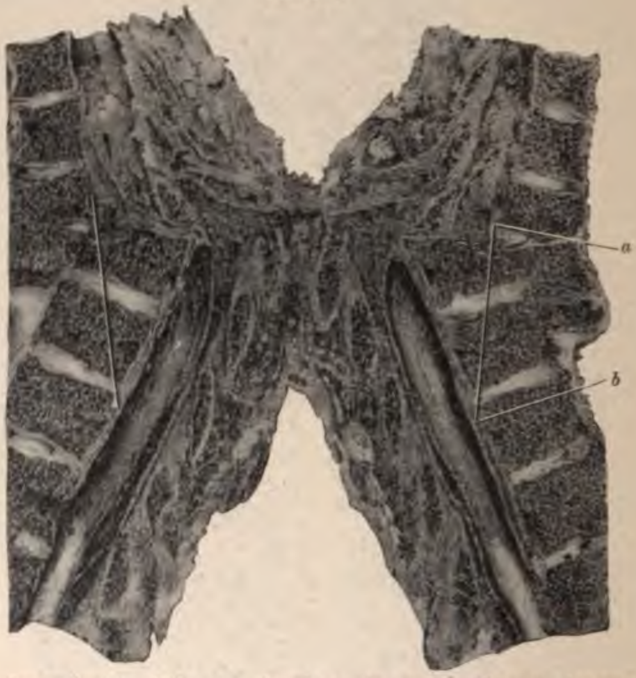
FIG. 255.



Osteoplastic resection. (Urban.)

If traumatic spondylitis follows some injury of the cord, or should tuberculosis or spondylitis deformans develop, there is no doubt that the individual is unable to perform manual labor. The same applies to fractures that are associated with permanent injuries of the cord. The conditions are not so easy when a case has healed; for instance, that of a workman whose fracture has become consolidated with more or less deformity without cord symptoms, or if these were present primarily they subsequently disappeared. Experience shows that individuals with marked deformity following fracture are at times able to perform heavy work. Patients with this sort of injury frequently suffer from hypochondriasis, as can be shown by more careful examination (increased reflexes, tremor, etc.), or they are more or less neurasthenic. The difficulties, however, may be great, because in some cases, on account of the displaced vertebræ, the weight-bearing line of the body has been altered. The muscles are already overtaxed provided the body is held upright and they cannot perform additional work. Certain of these patients are not able to bend over or straighten up without aid. They climb up on their legs with the hands as in Pott's disease. These sufferers easily become tired, and they have difficulty in resting. The frequent change of position that allows a healthy individual to rest is not possible on account of the partial ankylosis of the vertebral column. The patient is obliged to make use of his arms as a support while sitting in a chair. The older the patients, the worse their condition. The muscles and bones of a youth-

FIG. 256.



Severe fracture of the upper dorsal spine in a woman of twenty-five years.

ful individual are more liable to adjust themselves to the new static conditions, all of which must be considered in judging of the working capacity of those advanced in years and suffering from this condition. In judging of these people the examination should be extremely careful, and all symptoms complained of should be minutely investigated, for it is not always possible to detect simulation and exaggeration. In doubtful cases it is always best to err in favor of the patient and his family rather than in favor of the company.

Isolated Fractures of the Arches, Spinous Processes, and Transverse Processes.—Contusions of the vertebral arches and processes are unknown on account of the dense bony structure in this region. Even fractures in this region which frequently accompany complete dislocation occur very rarely by themselves.

Terrier's case, in which a spinous process was broken by muscular action, is unique. Fractures are usually produced by direct violence and are not infrequently combined with superficial loss of substance or with deep wounds.

Isolated fractures of the spinous processes occur most frequently in the dorsal region, although the other portions of the spine are sometimes affected. Several vertebræ may be injured at the same time. Swelling, effusion of blood, abnormal mobility, and crepitus establish the diagnosis. The symptoms are seldom severe. Occasionally a spinous process may be driven in between two vertebræ and into the cord itself. The long muscles of the back and the ligaments prevent any great amount of displacement, especially if these structures are put under tension by flexion, which may also aid reduction. Even in cases in which a pseudarthrosis has developed at the seat of fracture, the permanent disturbance is apt to be slight. Fracture of the arch itself is of much greater importance because there is likelihood of injury to the cord. A force acting from behind sufficient to break the vertebræ may displace the fragment into the vertebral canal. As a rule the force is applied directly to the spinous process and the lamella may be broken off on one or both sides. In the latter cases, in which the piece of the vertebra is completely mobilized, the danger of injuring the cord is, of course, much greater. Several neighboring arches may be broken at one time.

Fracture of the vertebral arch is much more common in the cervical region than in the dorsal or lumbar region. The atlas and axis are common seats of this injury. The atlas may be broken transversely and death usually takes place within a short time on account of the severe damage of the cord. When no cord symptoms are present, recovery is uneventful. It may, of course, happen later that the lumen of the canal is restricted on account of the callus.

Diagnosis.—The diagnosis will be made from the swelling, the extravasation of blood, local tenderness, abnormal mobility, crepitus, and cord symptoms.

Treatment.—In the cases not complicated by injuries of the cord the treatment consists simply in rest, but when the cord is injured radical interference is indicated. It has already been mentioned that fragments not infrequently produce permanent compression, and that the symptoms may be removed by operative interference. The technic of the operation has been considered.

Isolated fractures of the transverse processes have also been described. (Gostynski.) The diagnosis is difficult or may be impossible. These breaks are of little significance as far as life is concerned and the functional disturbance may be only temporary. The fragments reunite or become absorbed.

COMPLETE DISLOCATION WITH FRACTURE.

In partial dislocation of the vertebræ one of the columns of which the spine consists remains more or less intact. The pillar formed by the bodies, intervertebral disks and ligaments may suffer, while the arches with the transverse processes and the double column of articular processes remain intact, or the reverse may happen.

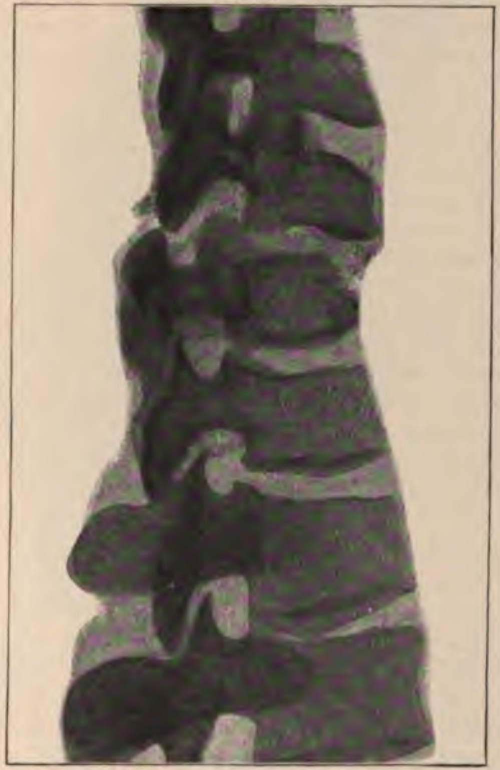
In complete dislocations with fracture the continuity of the anterior column and that of the articular columns behind are interrupted. There may be bilateral anterior dislocation of the articular processes or the latter may be broken off. The ligaments uniting the arches and their processes are torn in two. Fracture of the solid articular processes is uncommon, although the anterior column, consisting of the bodies in the vertebræ, suffers quite frequently. There may be a compression-fracture with slight dislocation, or a diagonal fracture with marked dislocation. Dislocation of the lateral joints may be associated with dislocation of the corresponding vertebral body, a condition which is termed complete dislocation. These complete dislocations affect the lateral joints and the disks between the same vertebræ —*i. e.*, in complete dislocation of the cervical vertebra the lateral joints and the body of the fifth vertebra slide over the corresponding portion of the sixth vertebra. The displacement is almost always anterior. In dislocations with fracture one or more vertebral bodies, usually the one immediately below, are fractured. In dislocations with diagonal fractures there is a dislocation in which the dislocated vertebra has carried with it the inferior disk and a portion of the vertebra immediately below. Sometimes, however, a portion of the synchondrosis and a fragment of the dislocated vertebra are left behind.

Marked dislocation, which may be so extensive that the dislocated vertebra comes to lie with its under surface on the anterior surface of the vertebra immediately below, constricts the vertebral canal considerably and often completely destroys the cord, because this structure is pressed against the upper edge of the lower vertebra while being carried forward. The accompanying diagrams of complete dislocations and complete dislocations with diagonal fractures make plain the mechanism of this sort of injury.

The gravity of these injuries depends largely upon the damage to the cord. As has been seen, the cord itself may remain intact in isolated injuries. Some cases are associated with hæmatomyelia. Where the cord is injured in the isolated cases the damage is apt to be partial. The cord may be simply compressed, and the prognosis is much more favorable than with total crushes, such as are common in complete dislocations. These severe injuries are hopeless as far as complete recovery is concerned. Death usually follows within a comparatively short time, because only the cauda equina is capable of regeneration.

Complete dislocations are an exaggerated stage of isolated bilateral dislocations. They are produced by extreme flexion—*i. e.*, indirectly. The patient may fall on his head or may be struck from above by some heavy weight. Direct violence, such as a blow from behind on the neck, may be followed by injuries of this sort on account of the sudden extreme flexion. Muscular action is probably rarely to blame. Complete dislocation backward, such as may follow overextension, is of little practical importance. This condition is rarely observed, and is amenable to no form of treatment whatever on account of the severe injury of the nerve-elements.

FIG. 267.



Complete dislocation of the fifth and sixth cervical vertebræ. Seen from in front and a little to one side. (Breslau Institute.)

In complete dislocations the ligaments are, of course, much more affected than in the isolated variety. The disk may tear off from the upper vertebra and show several fissures. Fragments of bone may adhere to the cartilage, which is noted quite frequently in connection with the upper anterior margin of the lower vertebra. The posterior lower portion of the upper vertebra is frequently left behind.

Complete rupture of the anterior and posterior longitudinal ligaments is uncommon, but they may be stripped off for a certain distance, usually down to the next intervertebral disk. The posterior one is separated from the dislocated vertebra and the anterior one from the vertebra below. (Fig. 257.) The posterior band covers the large venous plexus situated between this and the body of the vertebra, and when the ligament is torn as well as the vessels, an extradural hemorrhage takes place.

The intercrural, interspinal, and supraspinal ligaments, as well as the ligamentum nuchæ, are usually torn. It sometimes happens that the spinous process may tear off even with a portion of the arch and remain attached to the latter ligament. When dislocation is produced by some direct violence or by overextension, the injury may be followed by fracture of the spinous processes. The bands between the transverse processes are, of course, torn when these structures are not broken.

Fracture of the articular processes is important because in these cases it is extremely difficult to hold the injured spine in place.

The muscles, especially the deep-seated short muscles, are frequently torn, although the prevertebral muscles and fascia are not so frequently affected. Rupture of the pharynx and œsophagus has been sometimes observed, although it is of no practical importance, because the danger of infection does not add materially to the already hopeless prognosis. Fracture of the sternum, which according to Kocher is almost always present in total dislocations, should be looked for in these injuries.

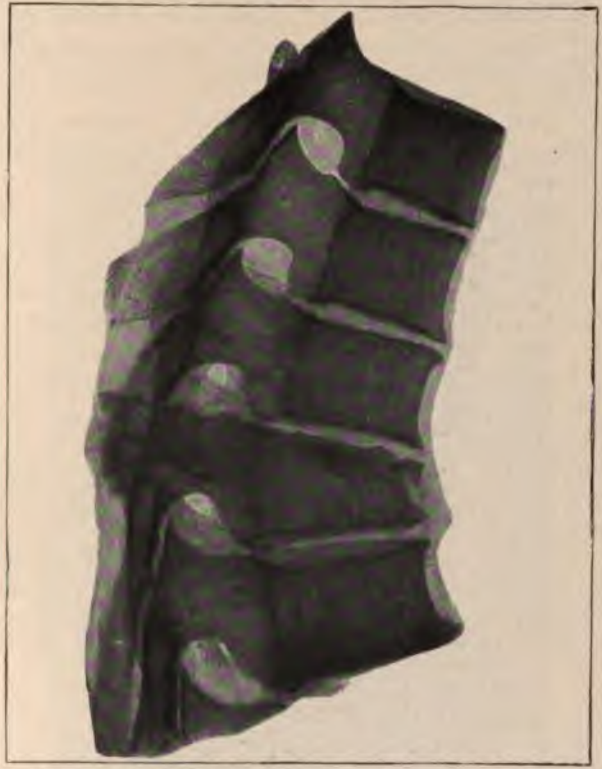
Complete dislocations are peculiar to the cervical portion of the spine, and are found much more rarely lower down. In the table, including 205 dislocations, collected by Wagner-Stolper, it is evident that bilateral dislocations are more common in the region where unilateral dislocations are not so prevalent. In the table the isolated bilateral dislocations are not distinguished from the complete dislocations.

Cervical vertebra.	Both sides.	Deaths.	One side.	Deaths.
	Per cent.	Per cent.	Per cent.	Per cent.
3.	7.1	70.0	22.5	18.2
4.	25.5	88.9	28.6	42.8
5.	30.4	76.7	24.6	25.0
6.	27.6	87.2	20.5	50.0
7.	9.2	92.3	4.1	100.0

The death-rate is lower, of course, than with complete total dislocations.

Dislocation with fracture in the majority of cases is an advanced stage of simple compression-fracture, and is produced by an excess of the same kind of force. When the compressed vertebra has become wedge-shaped, the surface next to the vertebra above is slanting, which favors dislocation of the overlying vertebra downward and forward. This is more apt to take place when the injury is produced by a force associated with flexion. When there are fracture of the body and dislocation of the lateral joints, the amount of total dislocation may vary greatly.

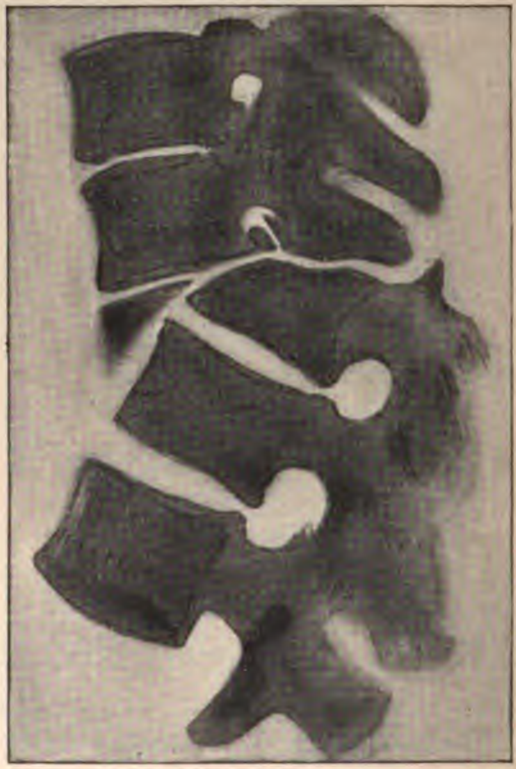
FIG. 258.



Compression dislocation-fracture between the sixth and seventh dorsal vertebræ. Male aged fifty-eight years, fell four weeks previously. Paraplegia. Fracture of the tip of the articular process of the seventh dorsal vertebra and small fragment in front. (Breslau Institute.)

The author distinguishes, as suggested by Kocher, a dislocation compression-fracture in which the fractured vertebra is impacted. The dislocation is relatively slight, and is much greater in dislocations with diagonal fracture. In the latter the dislocated vertebra slides downward and forward and takes with it a piece of the fractured vertebra. The line of fracture is usually from behind downward and forward. (Fig. 258.) Not infrequently the upper dislocated vertebra leaves a portion of its body behind, which remains connected with the main portion of the lower vertebra. In these cases the line of fracture passes through two vertebræ and extends from behind and above downward and forward. This variety is probably produced in the same way as the fractures in complete dislocation. The author saw that in these cases the dislocated vertebra was apt to leave the lower posterior portion of the body behind, while the upper anterior margin of the vertebra, over which it slid, was carried away. In dislocations with diagonal fractures, just as in complete dislocations, the displacement may be so great that the dislocated vertebra lies upon the anterior surface of the vertebra immediately below.

Fig. 259.



Complete diagonal dislocation-fracture of the twelfth dorsal vertebra, three weeks old. Fracture of the eleventh spinous process. Destruction of cord. (Breslau Institute.)

According to Kocher, three varieties of force are of etiological importance in dislocations with fractures: 1, compression from above downward; 2, flexion; 3, direct blow upon the back; or a combination of these. In the dorsal region, which is the favorite seat of dislocations with diagonal fractures, the first and second are most in evidence, and are produced by some weight increasing the normal curve of the column.

The incidental damage in dislocations with fracture is similar to that of complete dislocation. Instead of dislocation of the lateral joints, the articular processes may be broken off. Strictly speaking, one ought not to consider these cases dislocation-fractures, but complete fractures. Fracture of the articular processes, however, alters the clinical picture so slightly and is of so little importance in the after-treatment that it is not necessary to apply any special name to this condition.

The spinous processes may become broken just as in complete dislocations. (Fig. 259.) In complete dislocations with fracture the cord is in great danger. The liability to damage is greatest in dislocations with diagonal fractures in which the dura that usually remains intact tears. With dislocation compression-fractures the chances that the cord is not completely destroyed are somewhat more favorable. The mechanism of the crushing is the same as in complete dislocations, except that in front the posterior upper margin of the intact vertebra is not the portion producing the damage, but the remaining fragment, against which the cord is pressed by the arch of the dislocated vertebra.

Flexion as a factor in dislocation varies in importance in different regions of the spine. Its influence is greatest where the normal position is flexed—*i. e.*, in the dorsal region, where any compression in the longitudinal axis increases the curve. For this reason dislocations with diagonal fractures are found more often in the upper dorsal region or in the lower cervical region. In the lumbar region and in the lower dorsal region flexion is difficult on account of the normal lordosis, and for this reason dislocation pressure-fractures and isolated compression-fractures are more common here. According to Kocher, dislocation with diagonal fractures does not occur in the lumbar region.

Deviations from the above described types of injury are rather uncommon. Complete dislocation backward in connection with overextension of the neck has been reported. In the dorsal portion of the spine dislocation with fracture and backward displacement is possible. Kocher, Wagner-Stolper, and the Pathological Institute in Breslau possess records of this sort of injury. Kocher describes two cases in which the lateral joint-dislocation was unilateral and the fracture of the body was oblique, downward and outward. In these cases the injury was probably produced by extreme lateral flexion, and in one case the spine showed evidence of old scoliosis which would favor this view. It is evident that compression of the vertebral column in the longitudinal axis would tend to increase the lateral curvature.

There remains to be considered complete dislocation with fracture of the two upper cervical vertebræ, which condition presents certain peculiarities on account of the anatomy of these vertebræ. The injuries, generally known as a broken neck, are not all immediately fatal and are therefore of practical interest. The great danger of injuring the cord in this region is more or less offset by the relative size of the vertebral canal throughout the entire cervical region, especially in the section corresponding to the upper two vertebræ. There may be considerable diminution in the lumen before pressure-symptoms develop. The conditions in this respect are very unfavorable in the dorsal region. The only case of complete dislocation of the head is that reported by Wagner-Stolper. There was anterior dislocation with rupture of all the ligaments between the atlas and the skull. The individual died at once. The lax lateral joints do not offer much resistance to complete dislocation of the atlas on the axis, but the resistance offered by the ligaments of the odontoid process is far greater. Dislocation with rupture of ligaments only may follow: 1, rupture of the transverse ligament and transverse portion of the check ligament and, 2, when the odontoid process slips from beneath the constriction formed by the anterior arch of the atlas and the transverse ligament. In the latter case when dislocation is complete, the ligaments between the odontoid process and the skull must tear, as well as the union between the transverse ligaments and the axis. The elasticity of these bands may make it possible for a sort of subluxation to take place which may be reduced spontaneously; for instance, when one arm of the crucial ligament tears while the other remains intact. After rupture of these ligaments the lateral atlo-axoid ligaments do not give any material support. The only chance of preserving life is in the incomplete dislocations, for in the remaining cases the atlas is dislocated forward, and the cord, which is carried forward by the skull and the posterior arch of the atlas, is pressed into the odontoid process, which produces death immediately.

Dislocations with fracture may be produced by breaking off of the anterior arch of the atlas, or, more commonly, by fracture of the odontoid process at the neck. Wagner-Stolper reports a case of fracture in the region of the base of the odontoid process. Fracture may take place as an isolated fracture of the body of the vertebra without any great amount of displacement or dislocation. As a rule, however, a certain amount of dislocation is present, and there is always a tendency to have the head sink forward and to have the atlas become dislocated. Fracture in itself does not interfere with the lumen of the canal. The accompanying or secondary dislocation alone causes pressure upon the cord with fatal outcome. In Coste's case the cord symptoms did not appear for four months, and death took place four and one-half months after injury. In Küster's case the incomplete paraplegia disappeared under treatment, which was commenced fifteen months after the accident. Philipps describes a case of dislocation with fracture in which cord symptoms were absent in spite of a marked dislocation, because the posterior arch of the atlas, which had been broken off, was not dislocated. Autopsy reports show bony union of the odontoid processes, which demonstrates that life may be preserved at least for a certain length of time after this injury. It should, however, be remembered that a number of the traumatic fractures of the odontoid process reported are not really of traumatic origin proper, but occur in connection with caries.

Total dislocation, or dislocation with fracture backward, is much more uncommon, and only one case of lateral displacement has been as yet reported.

Etiology.—The causes of complete dislocation with fracture of the upper two vertebræ are the same as in other regions of the spine. The injury in dislocations forward produces extreme flexion, usually by a fall on the back of the head while the head is flexed. It is immaterial whether the individual falls himself or whether a heavy weight falls upon him. Direct violence, such as a blow upon the back of the neck, may produce a similar injury. Dislocation backward is usually secondary to overextension. (Krukenberg.)

Symptoms.—As far as the symptoms of complete dislocation with fracture in any region of the spine are concerned, they are the same as in bilateral isolated dislocation. The only difference is the increased displacement found in complete dislocation. At the seat of injury there is usually angular deformity, which, however, is not always marked. In the cervical and lumbar regions the normal lordosis must first be overcome before angular prominence becomes evident. Diminution or absence of lordosis may therefore be of pathognomonic significance. The displacement forward is best recognized by the spinous processes. The process of the dislocated vertebra will be depressed, or if broken off this depression will begin with the vertebra immediately above and the fractured spinous process will show evidence of increased mobility. As a rule, the spinous process of the vertebra immediately below extends beyond that of the dislocated vertebra and forms a prominence which is the apex of the kyphosis. In dislocation with fracture the apex of the kyphosis corresponds to the vertebra which has been broken. With flexion of the column around a point in the lateral joints the distance between the spinous processes is increased. The position of the cervical transverse processes may be felt at the side of the neck. The body of the upper three—*i. e.,* the arch of the atlas, the odontoid process, and the body of the third, as well as the corresponding three transverse processes—may sometimes be felt through the mouth and their relative position determined. Sometimes abnormal mobility of fragments may be appreciated by palpation through the mouth. When there is considerable displacement, as in complete dislocation, especially in the lower region of the neck, the difficulty in swallowing may be great.

Another symptom worthy of mention, aside from the swelling and effusion of blood, which may be marked when the arches of the spinous processes are injured, is the localized pain, which should be sought for. This is increased on pressure over the spinous processes or over any section of the spine which is accessible, sometimes even when pressure is brought to bear upon the soft parts. Experiments in this direction should be carried on very carefully, because they may b productive of dislocations with all their consequences. One shoul always avoid testing the sensitiveness to pressure by bringing weigh to bear upon the head or shoulders. It is equally unjustifiable for th same reason to test whether the patient is able to stand upright or no The history will oftentimes give sufficient data. The patient shoul never be allowed to sit up, and when examining his back he should b rolled on one side with the utmost precaution. Examination for th purpose of determining crepitus or any abnormal mobility is to be discarded, at least when done for this purpose only. These symptom will be discovered during the attempt at reduction or the history wil show that crepitus was felt during transportation. It is possibl to show that crepitus and abnormal mobility are quite common i recently deceased individuals with fractures of the vertebræ ar examined.

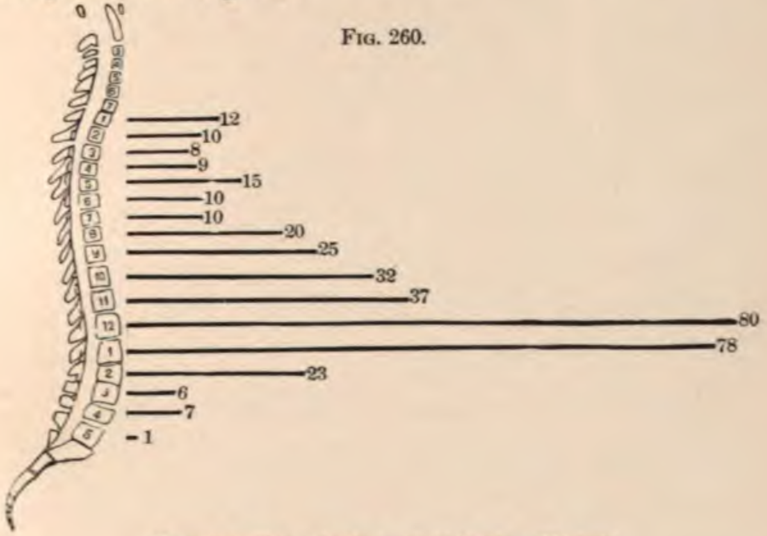
When there are symptoms of complete destruction of the cord, on should always suspect a complete dislocation with fracture. It ha been seen that it is frequently impossible to tell the exact extent of transverse lesion. Bearing this fact in mind, and remembering tha the remaining portion may be destroyed, the surgeon should use th greatest amount of precaution while examining patients, as well a during transportation and treatment. On the other hand, the cor symptoms enable the seat of injury to be located more accurately. Th injured vertebra may be determined with a considerable amount o probability without its being necessary to disturb the patient.

ISOLATED INJURY.		COMPLETE INJURIES.
Distortion; luxation; fracture of arch and spinous process (odontoid).	Upper two cervical vertebræ.	*Complete luxation fracture* *complete luxation.*
Luxations, especially unilateral distortion; fracture of arch and spinous processes.	Lower five cervical vertebræ.	*Complete luxations;* diagona luxation fractures.
Compression-fractures; spinous process fractures.	Upper dorsal vertebræ.	*Diagonal luxation fractures* luxation compression-fract ures.
Compression-fractures; spinous process fractures.	Lower dorsal vertebræ.	*Luxation compression-frac ures;* luxation and diag nal fracture.
Compression-fractures; spinous process fractures.	Lumbar vertebræ.	Luxation compression-frac ures.

Diagnosis.—It is not usually easy to make a differential diagnosi between the various sorts of injuries of the vertebral column. Th question whether there is partial or total injury may be determine with a moderate degree of certainty from the severity of the cor symptoms. They are, however, not absolutely reliable, because th nerve symptoms in the simpler lesions of the column may be at times extreme, while with total dislocation and fracture they may be relatively slight. Not infrequently it will be found impossible to tell for several days whether the injury of the cord is complete or partial. A certain number of the injuries, especially isolated dislocations of one of the lateral joints, distortion and fractures of the spinous processes or of the arches may present sufficiently characteristic symptoms. It is of diagnostic importance that the various sorts of injury involve different sections of the column. In the table on page 692 the injuries that predominate in a certain section of the cord are printed in italics and those that occur only exceptionally have been omitted.

The frequency of fractures in the dorsal and lumbar regions is indicated in the statistics of Ménard, including 385 cases of fracture and represented in Fig. 260.

Fig. 260.



Frequency of fracture in regions of spine. (Ménard.)

Treatment.—The clinical picture of total dislocations with fracture is governed almost entirely by the amount of injury of the cord. The prognosis depends entirely upon the extent of damage in this region. In the vast majority of cases treatment is of no avail and is largely symptomatic. When there is severe injury of the cord, it is useless to try to treat the injury of the spine.

Generally speaking, one should endeavor to reduce fracture and dislocations of the vertebral column. This is usually easy because the ligaments and muscles are considerably torn in complete dislocations with fracture, and there is no great amount of resistance to replacing the fragment. Traction in the long axis of the spine and pressure over the kyphosis will usually be sufficient. It is far more difficult to keep the bones in place. This may sometimes be done by placing a pillow beneath the seat of the kyphosis and applying extension-straps to the legs, head, and shoulders. In severe cases bedsores render this mode of treatment impracticable, especially as regards extension to the legs. When the head of the bed is elevated for the purpose of overcoming this difficulty, it becomes a problem how to manage the water pillows, the contents of which, of course, shift with the position of the bed. With injuries situated high up it may be possible to apply moderate extension to the head without counterextension. In the majority of cases, however, one is obliged to do without ideal treatment, because the patient is only tortured without doing him any especial good. The individual should be kept on a water pillow as flat as possible and the precautions already mentioned that apply in the treatment of paralysis should be observed. The water pillows should not be so full as to carry the weight of the body, but should allow the back to rest lightly upon the mattress, because a certain amount of immobilization is obtained in this way. In a permanent bath it is absolutely impossible to immobilize the patient, so that in spite of its great advantages it cannot be made use of in the recently injured. Later, when there is a certain amount of union of the fractured vertebræ, it may be tried—*i. e.*, after the third or fourth week.

Generally speaking the treatment consists in combating bedsores and cystitis. The question of improving the condition by laminectomy has already been considered. Should the cord in exceptional cases escape being crushed, and should there be no paralysis, or should existing paralysis show a tendency to improve, the treatment becomes more and more that of isolated fractures, especially that of compression-fractures, and has already been given.

STAB- AND GUNSHOT-WOUNDS OF THE SPINE.

Recent injuries of the spine do not demand surgical interference any more than stab-wounds of the cord. Antiseptic dressings should be applied and the wound should not be probed. When the damage is extensive, or the margins of the wound are much crushed and torn, it may be well to pack after enlarging the opening.

Fractures frequently follow gunshot-wounds, and occur especially in the region of the arches and their processes. The body is generally punctured or perforated, but is not apt to be so extensively destroyed that the power of carrying weight is impaired. Comminuted fractures of the bodies of vertebræ were uncommon with the old-style firearms, and are only exceptionally found with modern projectiles. The wound of exit may show splintering of the cortical layer. The arches and the processes, on the other hand, may be extensively splintered. Several arches and spinous processes may be destroyed by one and the same bullet, or neighboring processes may be fractured by the fragments that are driven against them. The bullet itself may become lodged anywhere in the region of the spine or entirely perforate this structure. There are added to the ordinary dangers of fracture two further disadvantages in gunshot-wounds: 1, the compound nature of the wound, and 2, the fact that the projectile or the splinters may injure the cord. Injuries to the other organs are frequently present and complicate the situation. Concerning the first complication, it is justifiable, as shown by experience, to consider the gunshot-wound aseptic. When the wound of entrance or exit involves the nasopharynx, or has perforated the stomach or intestines, this does not apply. Generally speaking, wounds of this sort are so dangerous that the prognosis is not especially affected by the additional danger of infection. The danger of infection is increased when the projectile carries foreign bodies, such as pieces of clothing, into the wound. This does not happen so frequently as might be supposed. The bullet and the fragments become of importance only when nervous tissue is compressed or contused. The danger to the cord is greater than with ordinary fractures, because there is not only the fragments of bone to be dealt with, but also the bullet, and furthermore the great force with which the fragments are driven apart adds to the severity of the situation. The cord may be torn, or when the track of the bullet is diagonal it may be destroyed for a considerable distance, or by chance only partially injured, which is perhaps more liable to be the case with bullets of small calibre. The lesion may be confined to the nerve-roots or to the trunk. Nerve symptoms may be entirely absent; for instance, when the projectile becomes lodged in the body of the vertebra and the cord is not damaged by fragments.

It is evident that in cases of gunshot-wounds vital organs may be injured at the same time, which complication is more dangerous to life than the injury of the spine itself.

Symptoms.—The symptoms of gunshot-wounds do not differ materially from those of other injuries of the spine and cord. The Röntgen rays will be of considerable value in the differential diagnosis, because the bullet may be located, which is also of great value from a therapeutic standpoint. Küttner was able to demonstrate in two cases in which the cord and the cauda equina had been perforated that the bullet was no longer in the vertebral canal. Lexer found a bullet which produced nerve symptoms in the transverse process of the first dorsal vertebra.

The Röntgen rays are not able as yet to locate bony splinters in the vertebral canal. When the fragments are extramedullary and have damaged the roots, they may be recognized with a fair amount of certainty. They produce the same symptoms as extradural or intradural tumors. Later a callus or cicatricial constriction may produce similar symptoms.

Treatment.—The treatment of gunshot-wounds of the spine does not differ very much from that of subcutaneous injuries of the spine. If the surgeon follow the rules laid down by modern military surgery, he will leave the wound alone and protect it from secondary infection by using an antiseptic dressing. Even when nervous elements are injured he will be inclined to adhere to this form of treatment. Gunshot-wounds of the cord demand interference just as little as crushes and stab-wounds. The operation serves only the purpose of removing the compression produced by fragments or the projectile. The x-rays are of great value in this direction, because it can be determined whether the pressure is exerted by the bullet or not. It will be necessary to decide whether there is a hopeless complete lesion, a partial injury, or whether there are splinters present. Later one will have to decide whether a callus or cicatricial contraction produces the symptoms.

In gunshot-wounds a differential diagnosis cannot be made for several days or weeks, so that one should generally wait for a time before interfering. An early operation is indicated only in cases in which the cord symptoms indicate pressure due to fragments or from the projectile. It remains to be decided whether in these cases it is not best to wait until the skin-wound has healed, so as to be able to operate with a greater chance of preserving asepsis.

As regards wounds of nerve-roots, it may be sometimes advisable to reunite the torn fibres of the cauda equina. It is, however, best to maintain an expectant attitude, because a large part of the paralysis produced by this sort of injury disappears spontaneously.

CHAPTER XXVI.

DISEASES OF THE SPINE.

ACUTE OSTEOMYELITIS OF THE VERTEBRÆ.

THIS disease has become more known of late on account of a series of observations. Only 43 cases have been described. (Hahn, Schmidt.) Hahn found that only 2 per cent. of the short and flat bones affected by acute osteomyelitis were vertebræ, and that the long bones were diseased 12 times as often as the short flat bones. Nevertheless the condition is of practical significance, and an early diagnosis is of the greatest importance on account of the relation of the vertebral column to its contents and to the large cavities of the body.

Osteomyelitis of the vertebræ, just as of other bones, is a disease of growing individuals. Of the cases reported in which the age was given, 12 were in individuals in the first decade of life, 14 in the second, 8 in the third, and 1 in the fifth, and 75 per cent. of the patients were under twenty years of age. The condition was almost twice as common in males as in females.

The lumbar region seems to be the seat of election, and was involved 17 times in 41 cases. The dorsal region is next in frequency with 12 cases, the cervical region with 9, and the sacrum with 5. The process not infrequently does not confine itself to one vertebra, but involves several.

Any portion of the individual vertebra may be attacked. It was formerly assumed that the body was most frequently affected, but recent experience does not seem to corroborate this statement. According to Hahn, the disease involved the body 14 times, the remaining portions 18 times, and all the vertebræ 3 times. The foci in the body are single or multiple; in one case the entire body was infiltrated with pus. The disease may be present in the arches or transverse processes as circumscribed foci, or there may be extensive necrosis. With smaller foci the sequestra are apt to be so small that they separate, and are cast off spontaneously through the incision or through spontaneous sinuses. The amount of bony destruction may be sufficient to produce deformity, although it has not been permanent in any of the cases described.

Trauma has been mentioned 5 times in the etiology; a blow upon the back or lifting of heavy weights, etc. The specific organisms are the well-known pus cocci, *Staphylococcus aureus* and *albus*, the former of which is more apt to produce a more acute, the latter a more chronic condition. The seat of entrance was supposed in one case to be a paronychia.

The process may extend and the pus may rupture into the joints of the spine, such as the alto-axoid or occipito-atloid or costospinal, or the pus may follow the tracks which will be considered later in connection with tuberculous suppuration. The abscesses developing from the bodies are usually found in the anterior region of the spine behind the pharynx or œsophagus if the cervical region is involved, or in the posterior mediastinum when the dorsal region is involved. In the latter case the pus may rupture into one or both pleuræ. When the lumbar vertebræ are diseased, the abscess may be in or on the psoas muscle. In the latter cases the pus may follow down into the hollow of the sacrum. Suppuration in the posterior region of the spine usually ruptures through the muscles and fascia and appears in the back. Once in a while, especially when the transverse processes are diseased, an abscess may be found in front and behind which connect with each other.

Involvement of the cord is of the greatest importance, and occurs not only in disease of the body, but also in that of the arches. Accumulations of pus in the vertebral canal may produce more or less extensive pressure-symptoms without direct involvement of the cord or its membrane. In other cases the pus-producing organisms may give rise to meningitis and myelitis. Riese reports a case of recovery in which pus was emptied through an incision in the dura. Disease of the cervical vertebræ is almost always followed by basilar meningitis. The nerves are involved in a considerable number of the cases, and sacral osteomyelitis is apt to be associated with sciatica. The initial symptoms of acute osteomyelitis of the vertebræ are those of acute infectious disease: high fever, chills, rapid pulse, coated tongue, slight albuminuria, diarrhœa, headache, delirium, and semi-unconsciousness, which may make it difficult to examine the patient for subjective signs. A certain number of the cases are less acute, and the disease does not develop sharply, but produces symptoms for weeks or months. As a rule the patients complain in the early days of marked localized pain, which appears spontaneously and on pressure over the affected region of the spine, thus preventing motion. Occasionally the pain is more diffuse. If the body of the vertebra is involved, pressure in the longitudinal axis may produce localized pain.

After a few days, hardly ever before the third or fourth, and often not until the eighth or tenth, an œdematous swelling appears which may be very marked and extensive. This swelling and the abscess will be observed earlier when the posterior region of the spine is involved, because the pus in these cases has a tendency to burrow backward. As a rule one is not able to locate the pus before the end of the first week, and generally not until the second or third. In a few of the cases the pus has not been found until four or seven weeks had passed. When the body and the beginning of the arches are involved, the pus may burrow backward, but it usually finds its way into the prevertebral regions, and can be detected early only where the anterior surface of the spine is accessible to palpation; for instance, in the upper cervical region, where retropharyngeal abscesses are to be sought for. Deep-seated abscesses are much harder to find as long as they are confined to the anterior surface. After rupturing into the pleura they may present as a pleural exudate. The abscesses developing in the lower dorsal region and upper lumbar region have never been detected early. The reason for this is that the patient dies of pyæmia long before the pus is detected. Before the pus reaches the surface these acute psoas abscesses produce symptoms referable to disease of the muscles, such as flexion at the hip-joint, that may be increased but not diminished on account of the pressure. Other signs due to irritation of the diaphragm have repeatedly been mistaken for evidence of peritonitis or typhoid. Makins and Abbott claim that these symptoms are due to involvement of the nerve-roots of the sympathetic ganglion. When the cord is involved, there may be symptoms of severe compression or of spinal meningitis. When the brain is involved, there may be symptoms of basilar meningitis. Rigidity of the neck is present in these cases, and is due to disease of the vertebræ themselves.

Diagnosis.—The diagnosis will be based upon local symptoms: sensitiveness to pressure, swelling, etc., although nerve symptoms may aid in indicating the seat of the trouble. Sometimes it is not easy to locate the lesion, especially if there are secondary symptoms, such as pleurisy, pneumonia, peritonitis, meningitis, etc., the signs of which may mask the lesion. Semi-unconsciousness may render examination difficult. For this reason many of the above complications have been considered primary and a diagnosis of typhoid or of Landry's paralysis has been made.

Prognosis.—As the condition becomes better known the prognosis gradually improves. Of 21 cases reported by Makins and Abbott, 15 died—*i. e.,* 71.4 per cent.; and if 4 cases mentioned by Riese, with 1 death, are added, the mortality will be found to be 64 per cent. Of the 43 cases published up to the present time, 26 died, a mortality of 60 per cent. If the 5 cases involving the sacrum are included, the death-rate will be found to be 55 per cent.

The prognosis depends upon the severity of the pyæmia secondary to the focus in the column, and upon the extent of the local process, and especially upon the involvement of important neighboring structures, such as the central nervous system. The sooner the process is recognized and attacked, the better the prognosis. The fact that disease of the arches is more easily recognized than that of the vertebral body explains why the prognosis in this condition is more favorable. The pus burrowing toward the back is less liable to produce damage than when the anterior surface of the column is affected, where the complications are apt to be grave. The view that the prognosis is worse the higher up the disease, is not tenable, as shown by Hahn. Four of 9 cervical cases died (44 per cent.); 5 of 12 dorsal (42 per cent.); and 12 of 17 lumbar cases (70 per cent.). Recovery was complete in 10 cases. In 1 paresis of the lower extremities persisted, and in 1 a sinus remained which was complicated by local recurrence; th deformity disappeared without leaving permanent sign or disturbanc of function. (Hahn.)

Treatment.—The treatment consists in early evacuation of pus and removal of the diseased bone if possible. This is not difficult when the arches and spinous processes are affected. It is not easy, however, to reach the foci in the body. Opening retropharyngeal abscesses from the mouth has many disadvantages, such as insufficient accessibility and difficulty in adequately draining the abscesses. These collections of pus are best attacked from without through an incision along the posterior margin of the sternomastoid, as recommended by Chiene. The large vessels of the neck are easily avoided with this method, whereas with Burkhardt's operation the incision is made between the sternomastoid and the larynx, and one is obliged to expose the large vessels, which may be very dangerous when prolonged drainage is necessary. When the abscess is situated along the anterior region of the dorsal vertebræ, the method recommended by Djakonoff, Parona, and Potarca is to be recommended. The transverse processes are resected with about 4 cm. of the corresponding rib. In this way the pus may be reached and sequestra removed. Heidenhain operated upon a case of acute osteomyelitis in this manner with success.

If the pleura has been perforated, the same indications apply as in the treatment of empyema. Psoas abscesses are best reached through an incision similar to that used for ligation of the common iliac. Great care should be taken, of course, not to open the peritoneum. An attempt to reach these abscesses from behind is only justifiable when the lower lumbar or sacral region is involved. This will not be possible without extensive resection of the lateral portion of the sacrum, the sacro-iliac joint, and perhaps a portion of the hollow of the sacrum.

Suppuration in the true pelvis along the anterior surface of the sacrum is best reached through the perineum or through a perisacral incision. Especial attention should be paid to ascertain whether the pus is in the vertebral canal or in the dura. If there is any suspicion that this may be the case, the canal should be resected and an exploratory puncture done. When the result is positive, the dura should be freely opened and the wound packed with iodoform gauze. As in osteomyelitis elsewhere, simple incision frequently does not diminish the symptoms. It will be fair to presume that in these cases the focus of disease is not sufficiently exposed or that there is pyæmic infection elsewhere. It may be necessary to attack the primary focus again or make incisions elsewhere into secondary foci.

When the bodies of the vertebræ are involved, one must always combat deformity just as in tuberculosis, by keeping the patients on their back or by supporting the diseased portion so as to overextend the spine. Extension may be applied, and before the patient assumes a sitting posture an appropriate corset may be necessary.

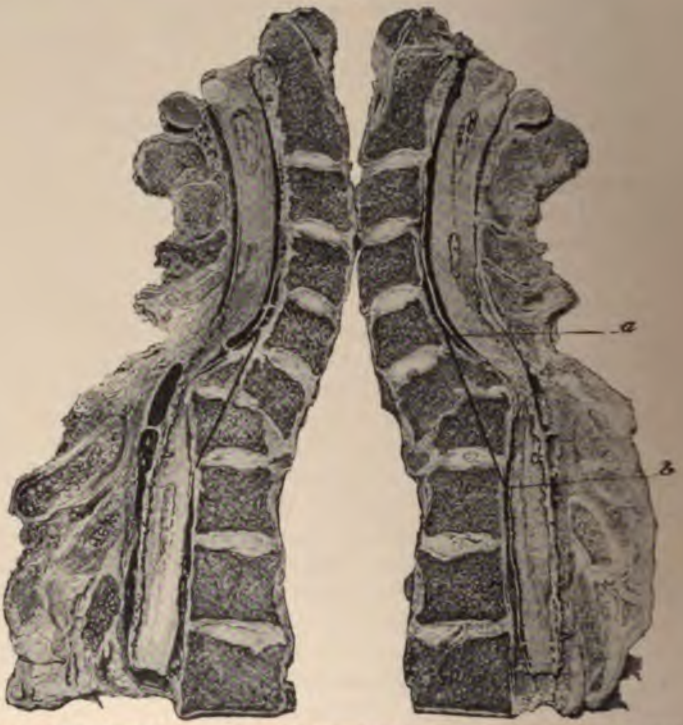
When the sequestra do not separate, secondary operations for their removal may be necessary. Two cases of this sort have been reported in which surgical interference became necessary after two and one-half weeks in 1 case and after five weeks in another. In 2 other cases the sequestra separated spontaneously after two and one-half weeks in the first case and eight weeks in the other. (Hahn.)

Quincke has recently described a spondylitis typhosa which appears as an acute osteomyelitis, runs a benign course, and disappears spontaneously without abscess formation or any appreciable infiltration. The number of cases reported are 7. The condition appeared two to three months after an attack of typhoid, and was associated with a varying rise in temperature of remitting character. The condition affected the lumbar and sacral vertebræ. The corresponding spinous processes were sensitive to pressure or there was tenderness in the region of the lumbar muscles. In some of the cases tenderness in the muscular regions was the primary symptom and the sensitiveness to pressure over the spinous processes appeared later. Pressure in the longitudinal axis of the vertebral column also caused pain. The spine may be held rigid on account of the pain in the muscles. In Neisser's 2 cases scoliosis developed, which in 1 case was supposed to be due to degeneration of the erector spinæ that was demonstrated microscopically. There may be swelling of the soft parts of the back in the region of the diseased vertebræ. A kyphosis appeared in 2 cases, which persisted after the other symptoms had disappeared. The nerve symptoms observed were paræsthesia, pains, slight cramp, a sense of weakness, and paresis of the muscles of the leg, increased or temporary absence of the patellar reflex, disturbances of the large intestine, retention or incontinence of urine. These nerve symptoms may in certain cases appear first. The treatment consists in keeping the patient horizontally in bed, using some plaster-of-Paris appliance, or local application of heat or cold. Morphine may be necessary for the pain, and quinine and antipyretics may be necessary for the evening rise of temperature. Prolonged warm baths and massage may help in restoring motion. All the symptoms disappear except perhaps the deformity. Slight cases last from three to four weeks, whereas severe cases drag on for two to three months.

SPONDYLITIS TUBERCULOSA.

Tuberculous disease of the spine is by far the most common inflammatory process in this region (Pott's disease). Vulpius calculated from the statistics of Billroth, Mohr, Lorenz, Hoffa, and Beuthner, that of 10,000 surgical patients, about 44 were cases of Pott's disease. Of 10,000 autopsies, 47 showed signs of this disease, which proves that the condition is three or four times more common than observed clinically. Accordingly to Vulpius, this condition constitutes about one-fifth of all bone diseases, and one-third according to Billroth-Menzel. The disease is most often seen in youthful individuals. More than one-half of the cases occur in the first decade of life ; the disease is rare in individuals over fifty years of age. The majority of cases occur in the first five years of life. (Beuthner.) Males are somewhat more frequently affected than females (53.25 per cent., 46.75 per cent.), but the difference is too slight to draw conclusions. Heredity is of some importance, but its influence is difficult to ascertain, as shown by the figures of Buthner (13.6 per cent.) and Gibney (76 per cent.). Trauma seems to be of etiological importance, and according to Taylor, 53 per cent. of the cases are supposed to be traumatic. Wiener, on the other hand, found of 47 cases, only 9 in which the relatives claimed that the primary cause was some injury, but in only 2 or 3 could a traumatic cause be found on analyzing the history. König does not attach much importance to this etiology because he claims that almost everybody has suffered from some injury or other in early youth by which the column might have been involved.

Fig. 261.



Pott's disease: the dark line indicates the portions of the bodies to be removed. (Urban.)

The condition seems to affect the portion of the column which is taxed greatest by weight-bearing and motion, so that traumatic processes in the widest sense of the word may be of etiological importance. According to Hoffa, the border-lines between the cervical and dorsal and dorsal and lumbar regions are most frequently affected; in adults the portion taxed most by weight-bearing, and in children the upper

region. The lower border region is affected most frequently by compression-fractures, as has been seen.

According to Billroth, cervical spondylitis is most common in the second decade of life. Vulpius found that the dorsal cases were most common in the first decade, whereas in the second decade the frequency of dorsal and cervical was about the same. The most recent statistics show that Hoffa's statement applies only to the lower dorsal and lumbar vertebræ, whereas the upper dorsal and lower cervical vertebræ are rarely diseased. The lower cervical vertebræ are, however, more often affected than the middle cervical vertebræ, whereas the atlas is quite rarely diseased compared with the axis, which is a frequent seat of tuberculosis. In the individual bodies of the vertebræ the disease starts preferably where compression-fractures are most common—*i. e.*, in front above and behind below.

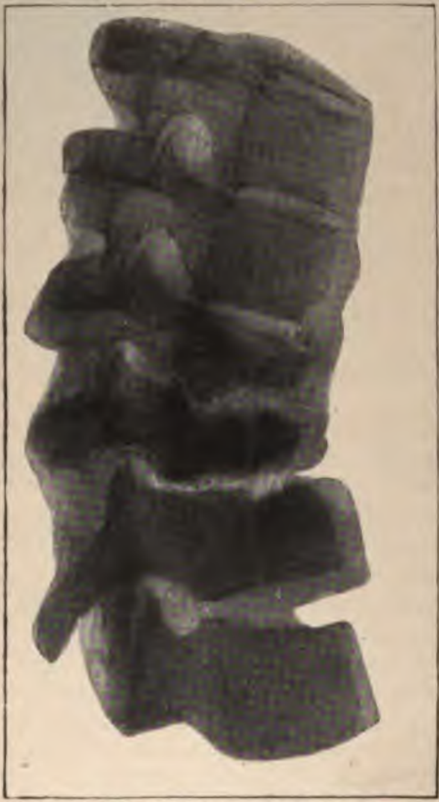
Pathological Anatomy.—Tuberculosis of the spine almost always attacks the bony portion of the body. The arches are rarely affected and tuberculous joints are found only in sporadic cases, and then usually in the upper cervical region.

Tuberculosis of the body appears in two forms; ordinary ostitis, in which the process extends from one or more primary foci, and involves one neighboring bone after another. The normal bone, or the sclerotic bone found so frequently in the vicinity of a focus of inflammation, becomes absorbed by the advancing granulation-tissue, or it forms minute sequestra (sand) that remain within the focus of disease. The tuberculous tissue undergoes typical changes in this region as elsewhere. Extensive segments of the body are destroyed and the bone is replaced by caseous granulation-tissue. If the process is arrested, there remains a cavity filled with the products of disintegration which is separated from the sclerotic bone in the immediate vicinity, and the rarefied bone around this by a membrane consisting chiefly of miliary tubercles. In many cases the tuberculous tissue disintegrates so rapidly that the granulations are unable to absorb the bone and the dense bony structure dies *in toto.* Cheesy sequestra are formed, which are surrounded by a zone of inflammation separating them from the healthy bone. The bone in the immediate vicinity is sclerotic, and at a distance from the focus it may show signs of malacia. The marked hyperæmia always present is especially noticeable in the marrow of adults, although this increased redness is at times observed in children. The line of demarcation is usually formed by a thin layer of tuberculous granulations.

The sequestrum in the vertebræ is frequently wedge-shaped, and in the early stages it is difficult to distinguish from normal tissue. The circulation in the necrotic portion is gradually shut off, and the color changes from red to a grayish red, and finally becomes yellowish white. Macerated preparations show the sequestra only after demarcation has formed. According to König, this process in several neighboring vertebræ is due to emboli aided by the altered circulation and diminished resistance of the tissue.

The final result of all types of tuberculosis with or without sequestra is the same—*i. e.*, destruction of the bone. The vertebral bodies lose their firm consistence, and when the column is required to carry weight in the usual way it gradually bends or breaks off suddenly. A kink is produced, the hinge of which is as a rule in the lateral articulations that remain intact. The vertebræ situated above and below the focus become approximated, but touch only with the anterior edges of their respective bodies, because the arches and lateral joints behind remain intact. It is evident that the portion of the vertebra behind the hinge becomes separated, as shown by measuring the distance between the spinous processes. The kink is most marked when only one vertebra is affected. When several neighboring vertebræ are diseased, the deformity is more apt to be round rather than sharp. If, however, one vertebra is more especially affected, as is the case when the process has extended from the body of one vertebra to the neighboring vertebræ, the deformity is apt to be more angular, and the apex of the kyphosis will be formed by the spinous process of the primarily diseased vertebra. As a rule, several vertebræ are involved, and in the dorsal region quite a number are apt to be diseased. (Ménard.) According to Beuthner, autopsies show that one or two vertebræ were affected alone 10 times; three to five, 31 times; more than five, 19 times. According to Bouvier, one or two were affected 31 times; three to five, 26 times; and more than five, 24 times. Vulpius calculates that in 40 per cent. of the cases three to five vertebræ are affected, whereas a fewer or greater number are affected in about 30 per cent. each way. From what has been said, it is evident that the deformity of the spine is a kyphosis.

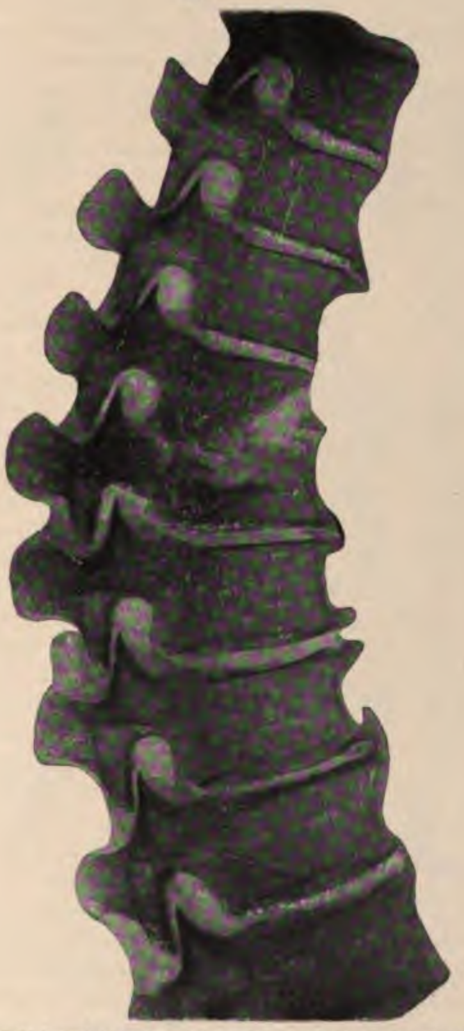
FIG. 262.



Caries of sixth to ninth dorsal vertebræ, prevertebral abscess. Compression of cord. (Breslau Institute.)

If appearing in the region of the spine where the curve is normally a lordosis, the latter must first be overcome before a kyphosis can develop. When the tuberculous process does not involve the halves of the bodies evenly, there may be a certain amount of lateral deformity with the concavity toward the side most affected. The angle of the deformity depends on the amount of bony destruction, and may vary from a slight prominence of one spinous process to extreme sharp, angular deformity. There may be no deformity whatever, especially with small foci, where a relatively large portion of the supporting tissue of the vertebra is left intact, as in early tuberculosis and in the cases in which extensive destruction is associated with considerable new

Fig. 263.

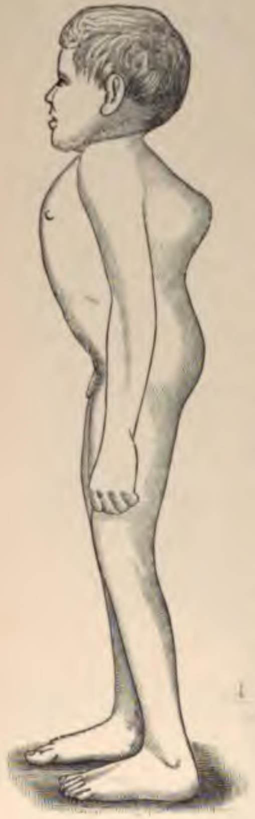


Caries of sixth to seventh dorsal vertebra. Suppuration of intervertebral disks. Prevertebral and postvertebral suppuration, two years after fall into cellar. (Breslau Institute.)

formation of bone. This is the case when the anterior longitudinal ligament becomes ossified. (Fig. 263). The greater density of the bone in adults explains why an angular deformity is more uncommon than in children.

The anterior displacement of the column at the seat of disease is offset by posterior displacement in the neighboring portions. The dorsal vertebræ, which are normally kyphotic, first become straightened and then show lordosis. The upper and lower portions of the spine take part in this compensation to an equal degree. When the deformity is low down in the lumbar region, the hip-joint becomes overextended, whereas the angle of the pelvis is diminished. The amount of extension possible in the hip-joints is limited and can compensate but slightly for deformity in the lumbar region. When the angular deformity in this region is marked, the power of maintaining an erect position is lost; after recovery, patients of this sort are only able to move about on "all-fours." The increased lordosis in the lumbar region necessary for compensation in dorsal disease is associated with an increase in the angle of the pelvis and flexion at the hip-joint.

FIG. 264.



Spondylitis dorsalis.

The deformity in the dorsal region corresponds to a pathological increase of all physiological curves of the spine, and the distance between the head and the pelvis is diminished to such an extent that the patient seems shortened. (Fig. 264.) On the other hand, when compensation takes place partly in the dorsal region, a certain amount of this shortening is overcome again by extension. (Figs. 265 and 266.)

The changes in the chest are of great importance, and the position of the upper portion of the spine influences greatly the position of the ribs in this region. When the deformity is in the upper dorsal region, the ribs will be inclined downward and become approximated to the spine. The chest assumes a flat and shallow shape. (Fig. 267.) The reverse is the case with lordosis in the upper dorsal region. The ribs are lifted up and the thorax shortened, whereas the anteroposterior diameter is increased. (Fig. 268.) In the latter cases the thorax is permanently in the position assumed on extreme inspiration and the movements of respiration are partially or completely abolished, so that the diaphragm is obliged to do additional work. The diminution in the angle of the pelvis to the horizonal in lumbar disease lower down brings the symphysis nearer to the ensiform cartilage and shortens the abdomen. The abdominal contents make room for themselves by pressing the parietes forward. The conditions are very complicated when there are several foci at different levels. Deformity may appear in both positions, which is compensated for by lordosis in the remaining portions of the spine.

FIG. 265.

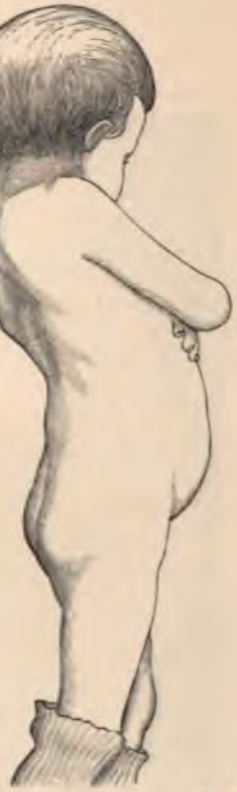
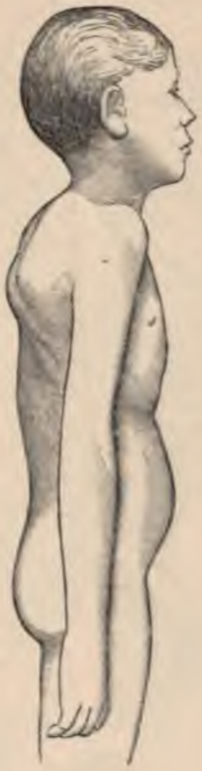


FIG. 266.

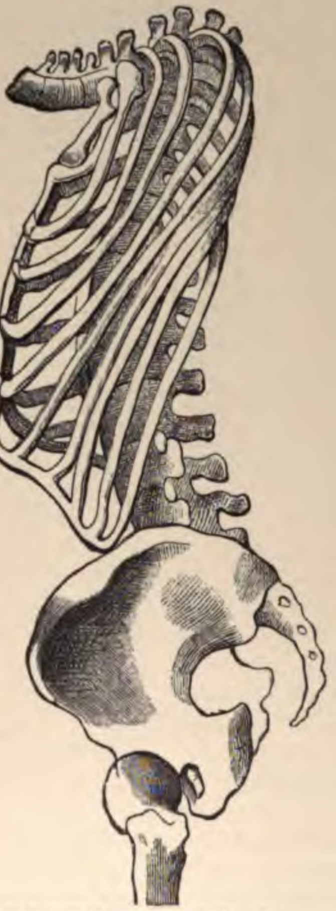


Spondylitis dorsalis.

With tuberculous disease in the lumbar region the pelvis gradually develops a characteristic shape and becomes kyphotic, as it were, for the anterior posterior diameter is increased and the transverse diameter diminished, especially at the outlet. The skull itself undergoes changes corresponding to a kyphosis. The occipitomental diameter is considerably increased, whereas the fronto-occipital diameter is diminished. These changes explain why patients with this disease are so apt to resemble each other. (Witzel.)

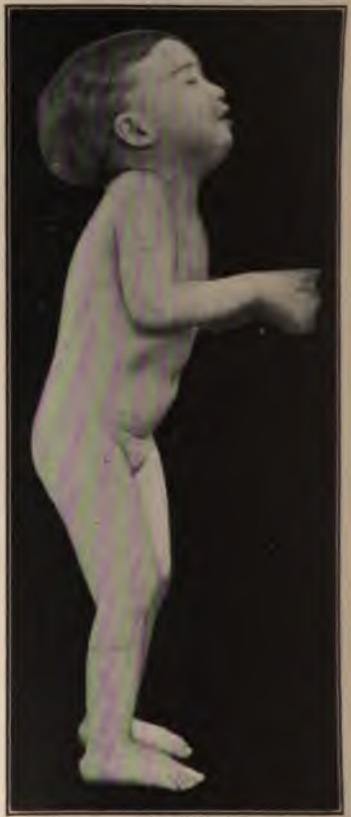
Secondary changes of the internal organs affect the large vessels and the œsophagus chiefly. The aorta is closely united with the spine on account of the intercostal arteries, and is obliged to adapt itself to the deformity, and may be more or less kinked. This condition may be followed by insufficient blood-supply to the lower section of the body and hypertrophy of the left ventricle. Similar changes may take place in the vena cava, although it is far less adherent to the spine. For this reason stenosis of this vessel and venous congestion of the lower half of the body are correspondingly uncommon. Both artery and vein may be pushed forward by a cold abscess. The connection between the œsophagus and the spine is loose, provided the structures are not bound together by inflammatory adhesions. There is no tendency for the œsophagus to follow the curve of the spine, and its position bears the same relation to the vertebræ as the string to a bow. When certain portions of the œsophageal wall

Fig. 267.



Deformity in upper dorsal region.

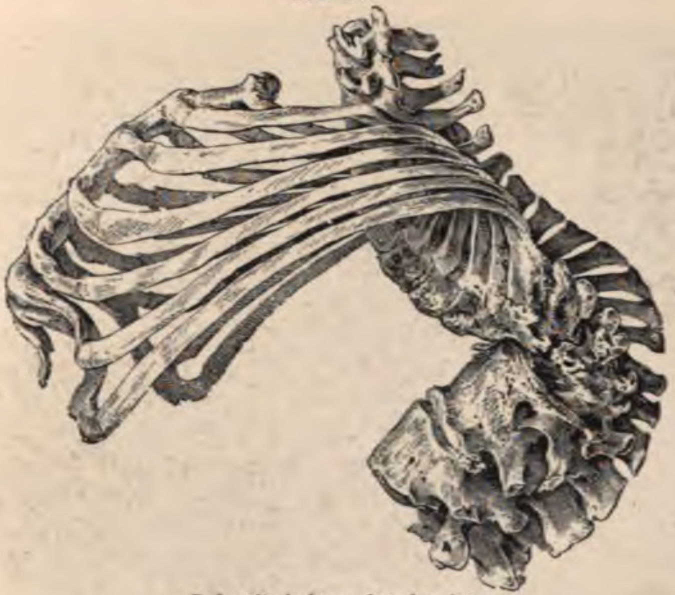
Fig. 268.



Disease of the upper dorsal region. Characteristic attitude. (Whitman.)

are adherent to the spine, they may be drawn out and form diverticula. Stenoses produced in this way are uncommon. Diseases in other organs are more distinctly secondary. Hypertrophy of the right ventricle may follow insufficient aëration of the lung, due to the thoracic deformity and abnormal pressure. Rokitansky's claim that tuberculosis of the lung does not occur with tuberculous disease of the spine applies to the extent that fresh foci of pulmonary tuberculosis are rarely found when the deformity of the spine is sufficient to produce congestion of the lungs. The changes in the cord will be considered later.

FIG. 269.



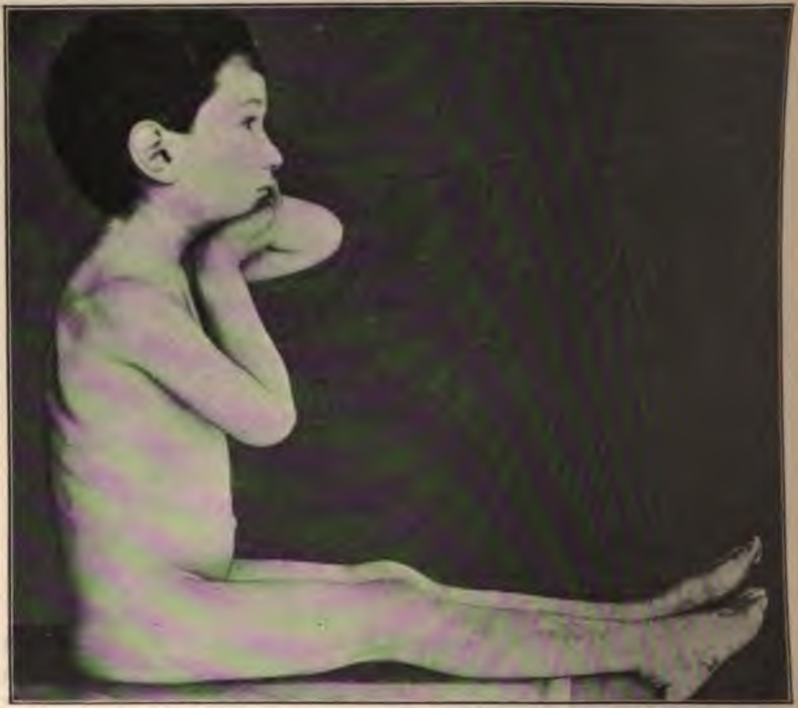
Deformity in lower dorsal region.

Tuberculosis of the vertebræ is due to hæmatogenous infection, but after having become established the process may extend in various ways after reaching the surface of the vertebræ. If the upper or lower epiphysis becomes involved, the intervertebral disks are attacked and become disintegrated, leaving cheesy sequestra of varying size behind. The adjoining vertebræ are next involved directly.

The primary seat of tuberculosis is usually in the anterior portion of the body, and the pus ruptures anteriorly in the majority of the cases. The long anterior vertebral ligament is lifted off and the process extends as a cold abscess. This ligament is separated not only from the body immediately affected, but also gradually from the neighboring vertebræ and the abscess advances downward, between this band and the vertebral column, following the law of gravity. At the openings of the vessels in the vertebræ below, the tuberculosis finds a new place of entrance, and the granulations involve a varying number of vertebræ in this way. A spine of this sort after maceration has a worm-eaten appearance. (Vermoulure.) In rare cases the process is supposed to be confined to erosion of the surfaces of the vertebræ (Boyer, Busch) without producing extensive foci of disease (spondylitis superficialis, caries peripherica). Hoffa believes that a certain proportion of these cases are of actinomycotic origin.

Suppuration takes place in the vast majority of the cases. On autopsy abscesses are found much more frequently than during life. Vulpius calculated from the autopsies of Bouvier, Lannelongue, Nabel, and Mohr, that suppuration complicated 80 per cent. of the cases, whereas clinically abscesses were found in only 24.5 per cent. of 1945 cases. The lower vertebræ are most frequently affected, the dorsal least, because in these cases the pus cannot be demonstrated clinically. These cold abscesses follow certain anatomical tracts where there is the least resistance. The tendency to wander is favored by the constant increase in the size of the abscess. The course taken is usually downward, although the opposite sometimes occurs, which proves that gravity is not the only force determining the direction in which an abscess extends. New tissue is constantly becoming infected by the tuberculous virus contained in the pus.

FIG. 270.



Cervical disease. A characteristic attitude. (Whitman.)

The pus itself as shown by animal experiments (Garrè) is infectious. The peculiarities are those of tuberculous pus in general: it is white, yellowish white, or brownish, frequently contains cheesy masses or small sequestra, which in small abscesses may be so abundant that the pus has a gruel-like consistence. Microscopically the pus is shown to consist of detritus with few leucocytes or none at all. Sometimes the abscess contents are clear, yellow or yellowish brown, and of syrupy consistence. These serous abscesses are observed when the process has a tendency to heal. The pus is surrounded by a typical membrane consisting chiefly of miliary tubercles. In the immediate vicinity of the cavity itself there are marked signs of caseation, and toward the normal tissue a layer consisting of old and recent granulation-tissue. (Bruns and Nauwerck.) The pus contained in abscesses of this sort may amount to several quarts.

The tracts followed by cold abscesses have been shown by Henke, König, Witzel, and A. Schmidt, to differ in different portions of the spine. The author will consider them separately, although the differences are not sharply drawn, for the pus of the first vertebra of one group and the last of another may follow the same course.

It has been mentioned that the pus usually lifts off the anterior longitudinal ligament. The ligament may be perforated, which is uncommon; or the pus may work out to one side, which is the usual event. An abscess developing in the upper cervical region appears in the retropharyngeal or retro-œsophageal space. One commencing high up may sometimes reach the retrovisceral tissue and follow the œsophagus into the posterior mediastinum as far as the aorta, which it accompanies downward. In the region of the entrance to the larynx it may not only produce difficulty in swallowing, but also difficulty in breathing. The ordinary course it takes after surrounding the œsophagus, trachea, and thyroid gland is to follow the inferior thyroid artery to the subclavian region and point either above the clavicle in front or behind the sternomastoid, or to follow the large vessels and nerves into the armpit and point in this region. Occasionally abscesses situated high up find their way beneath the buccal fascia and point anteriorly in the carotid region or on the cheek. Abscesses in the upper cervical region rarely follow the œsophagus into the posterior mediastinum, although this is the common route taken by abscesses low down. The former follow along the inferior thyroid artery, whereas the latter are not so apt to take this course. Abscesses may perforate the pharynx or open on the neck before or behind the sternomastoid or in the armpit. Several cases have been reported in which the vertebral artery had become eroded. (Regnier, Hasse, Leguest.)

Abscesses due to disease of the dorsal vertebræ rarely follow the course of an intercostal artery. When they do, the pus points in the lateral region of the chest and may break through in this region. They usually follow the aorta. This vessel and the vena cava may become surrounded by pus or lifted off and in rare cases eroded. (Bardenheuer, Dewes.) It has already been mentioned that the œsophagus is usually lifted off from the spine, and that it is adherent to this structure only in exceptional cases. When this condition is present, abscesses that otherwise would come to lie behind the œsophagus may rupture into this tube. Generally speaking, the abscess follows the aorta through the diaphragm down into the pelvis. The pus finds its way into the loose retroperitoneal connective tissue of the iliac fossa and spreads out usually over and rarely beneath the common iliac artery. The abscess becomes palpable in this region and extends later along the external iliac and femoral artery. The pus may point in the region of the middle portion of Poupart's ligament or may follow the artery downward and rupture in the popliteal space. The pus may extend forward in the subperitoneal connective tissue and may appear outside of the peritoneum in the anterior abdominal wall above Poupart's ligament. Sometimes it reaches the loose connective tissue of the cord and extends downward into the scrotum and ruptures there. The abscess may not follow the external iliac at all, but take the course of the internal iliac into the true pelvis, which it leaves through the greater sciatic notch with the sciatic nerve and produces a swelling beneath the gluteal muscles. In the posterior region of the thigh the hip-joint may become involved. Abscesses due to disease of the dorsal vertebræ may rupture in various places. The thoracic cavity or the peritoneal cavity is rarely opened, and the pericardium still more rarely. Adhesions usually form first, which are followed by perforation into the lung, the œsophagus, the intestine, or into the bladder. Abscesses in the true pelvis may point at the side of the anus and be mistaken for prostatic processes or after perforation for fistula in ano.

Abscesses of the lumbar region and of the lower dorsal region after escaping from beneath the long anterior ligament rupture into the sheath of the psoas muscle, which is connected with this band (psoas abscess). This is the usual course taken, although in exceptional cases the pus may reach the aorta and follow one of the tracks already described. The sheath of the psoas muscle becomes distended with pus, which accumulates between the muscle itself and its fibrous covering. Sometimes the muscle itself is infiltrated and the interstitial tissue destroyed. In these cases the pus usually points in the anteromedian region of the thigh.

The psoas bursa is frequently involved by these abscesses, and as this structure may communicate with the hip-joint, there is danger of extension in this direction. The close connection between the psoas and iliac muscles explains how the latter is so frequently involved secondarily by the process (iliac abscess). The psoas is only partially separated from two other muscles or groups of muscles—*i. e.*, from the abductors and quadratus lumborum—which explains how pus at times ruptures into one of these. The abscess may follow downward along the inner surface of the thigh in the adductor region and point anywhere in the course of these muscles. The quadratus guides the pus to the lateral region of the spine and allows it to point between the ribs and the brim of the pelvis. In rare cases the fibres of the transverse abdominal muscle derived from the lumbar fascia guide the pus forward to the anterior surface of the abdominal wall even as far as the umbilicus.

When the last lumbar vertebra is involved, the abscess may develop behind the psoas because this muscle has no fibres from this vertebra. The pus follows the ileolumbar artery and reaches the iliacus directly. (König.) These iliac abscesses point beneath Poupart's ligament between the margin of the iliopsoas tendon and the median border of the rectus. They usually undermine the latter muscle and point at its outer side between it and the tensor fasciæ femoris. When the pus perforates along the median margin of the rectus, the abscess is apt to rupture into the sheath of the sartorius muscle or follow the sheath along and reach the surface somewhere in the course of this muscle. As these abscesses arise in the median line, it is not uncommon to have them descend on both sides at the same time. Psoas abscesses are especially liable to be bilateral. There is frequently a communication in front of the diseased vertebra between the two pus cavities.

The abscess cavity, which is long and drawn out, does not always have the same diameter, as shown by Nélaton. There are dilatations and constrictions, the latter of which may obliterate the continuity of the sac. The above remarks apply to disease of the bodies of the vertebræ. Tuberculous disease of the arches and its processes is much more uncommon. When present, the foci are usually small, frequently containing sequestra, and form the starting-point of suppuration. The pus points in the back somewhere near the median line, and is apt to appear symmetrically. The abscess, however, may follow the vertebral canal, a course which is not commonly taken by abscesses of the bodies of the vertebræ. In the latter cases the pus may have ruptured through the posterior wall of the body or have extended backward into the canal through the intervertebral foramina. The effect of abscesses in the canal may be either compression or infection of the cord or of its membrane. Both of these conditions may be present without pus, and be produced entirely by tuberculous granulations that have infiltrated the canal. Compression and infection are usually present at the same time. Compression is more apt to be present alone than infection, and is due to bulging of a tuberculous focus or of pus into the lumen of the canal. It is far more common to have the dura become infected and have a pachymeningitis tuberculosa externa develop. It has already been considered how disease of the dura presses upon the nerve-tissue because of the accompanying œdema of the cord. It has also been mentioned that it is extremely rare to have the process extend from the dura to the pia and to the cord itself. The nerves leaving the cord may be involved in the same way as the cord.

Compression may not only be produced in the manner described, but may also be due to bony stenosis of the vertebral canal. This is not common. The lateral joints remain resistant and a condition develops resembling that of compression-fractures. It has already been emphasized that with the latter injury compression of the cord is rare.

The amount of kinking in the vertebral column in tuberculous processes may sometimes be much more marked than in fractures. Kraske probably goes too far when he claims that only 2 per cent. of the cases of compression are due to osseous diminution of the lumen. Trendelenburg believes that paralysis due to change of position is of considerable importance, because in 5 of 8 cases in which he performed laminectomy he found only a diminution in the lumen of the vertebral canal, but no tuberculous tissue.

According to Vulpius, 12.7 per cent. of the spondylitis cases are combined with cord symptoms. Nerve symptoms are rare when the disease is in the lower lumbar region, and are most common when the cervical region is affected, according to Vulpius. Other authors, such as Billroth, Dollinger, and Bouvier, claim that cord symptoms are much more common with disease in the dorsal region.

Symptoms.—The symptoms of Pott's disease are due to the destructive process in the bone itself that changes the shape of the spine and is followed by local pain. Besides this, the abscesses and the effect of the disease on the contents of the spine are of importance in this direction. It is known that symptoms may be absent although the condition has existed for a long time, while it is, on the other hand, not uncommon to have certain symptoms present when others are absent or but slightly marked.

One of the most common initial symptoms is local pain with sensitiveness to pressure over the diseased portion of the spine. Only the bodies of the upper cervical region, and in lean individuals those of the lumbar region, are directly accessible to palpation. Pressure may, however, be brought to bear indirectly upon the remaining vertebræ. The spinous process is not infrequently sensitive to pressure. Attempts to detect hyperæsthesia of a spinous process by applying a hot sponge (Copeland) or by galvanization (Badin, Rosenthal, and Seeligmüller) have no practical value because of inaccuracy.

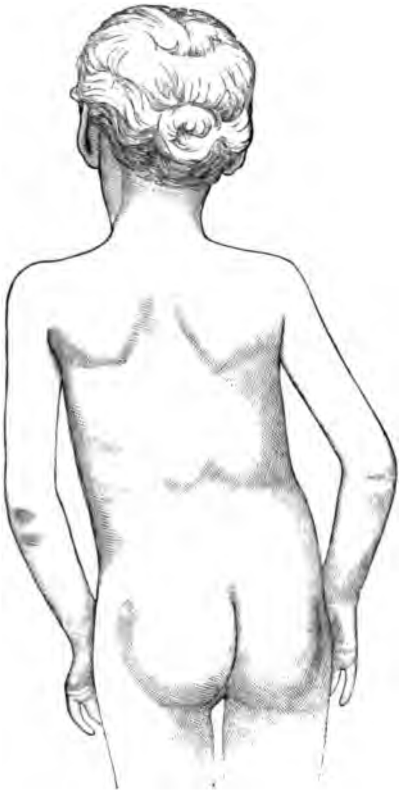
Slight tapping over the spinous processes with the fingers or with a percussion-hammer will frequently produce characteristic pain.

It is possible to press upon the bodies of the vertebræ directly by applying force in the long axis. It is characteristic that carrying weight and overexerting the weight-bearing function of the bodies will produce pain in the affected region. It is not without danger to test the patients by directing them to jump from a chair so as to increase momentarily the degree of pressure. The same applies to sudden pressure brought to bear upon the head and shoulders, because the weakened bones may be crushed in. It is only justifiable to press gently upon the head and shoulders, which will usually be sufficient to produce well-marked localized pain in the diseased region. In many cases simple physiological weight-bearing may be sufficient to produce pain, and the patients will locate this symptom on sitting up or on standing, whereas on lying down it disappears. When the disease is situated in the lumbar region, standing is easier than sitting, because in the latter posture the tendency to flex the spine anteriorly compresses the bodies of the vertebræ, while on standing the position is that of lordosis. Sometimes it is possible to bend the body forward up to a certain point, beyond which further motion is accompanied by agony. The patients suddenly cry out and support themselves immediately upon their arms. The arms are often used as supports. In cervical disease the individual may try to relieve the weight of the head by supporting the same with his hands either on both sides or beneath the chin and occiput. When the lower region of the spine is affected, the patient is apt to brace his arms while sitting down, so as to sustain a certain proportion of the body weight. Lying down does not necessarily prevent pain, for sudden motion, such as may take place during sleep, produces this symptom immediately and the individuals cry out in sleep ("night cry"). Coughing, sneezing, and laughing are apt to produce pain on account of the sudden expiration and a tendency to flex the spine at the same time. The patients try to guard against and limit all painful motion by removing as much weight as possible from the vertebræ and keeping the spine quiet. The longitudinal muscles of the back are held rigid and flexion is carefully avoided. The patients' attitude is one of anxiousness and their gait is awkward. The manner in which they pick up objects is characteristic: they bend the knees and flex the hips, keeping the back stiff and vertical until the hand reaches the object desired; in getting up they aid extension of these joints by supporting the body upon the arms; the hands are placed upon the flexed knee, and they gradually straighten the body by gripping the thighs higher and higher. When arising from a horizontal position the arms are also made use of as supports. The entire column is not necessarily held rigid. Sometimes only the diseased portion is the part that does not partake of flexion. On placing a hand over this region one observes that the spinous processes on flexion do not change their relative position. This is a very constant symptom, and may be present before there is any deformity, and is the more marked the greater the normal amount of motion in the region of the spine affected.

Besides sensitiveness to pressure, there is not infrequently spontaneous pain in the diseased region, which does not disappear on lying down. This is very annoying and is frequently present as a dull thumping in the chest or abdominal cavity synchronous with the pulse. The patients complain of stomach-ache, which is especially liable to be the case when the pain is increased after eating, although the function of the stomach and intestines is perfectly normal. According to Judson, abdominal pain of this sort is as important a symptom of early Pott's disease as pain in the knee is of hip disease.

In young children unable to talk it is needless to say that the pain is not located. As a rule all that is noted is a change of temperament. Children that have been active suddenly become cross and do not care to play. They cry when raised, and try to avoid any motion of the back by keeping the muscles rigid or by constantly lying down. The rigidity of the column is due to the tension of the muscles for the purpose of diminishing the amount of motion and is partly reflex. Sometimes the absence of motion locally is due to anatomical conditions because the ligaments may become ossified and ankylosis of certain sections of the spine may develop. The characteristic sign of a local process is deformity of the column. This develops gradually as a rule, and appears at first as a slight prominence of one spinous process, but in time becomes a marked angular or rounded prominence.

FIG. 271.

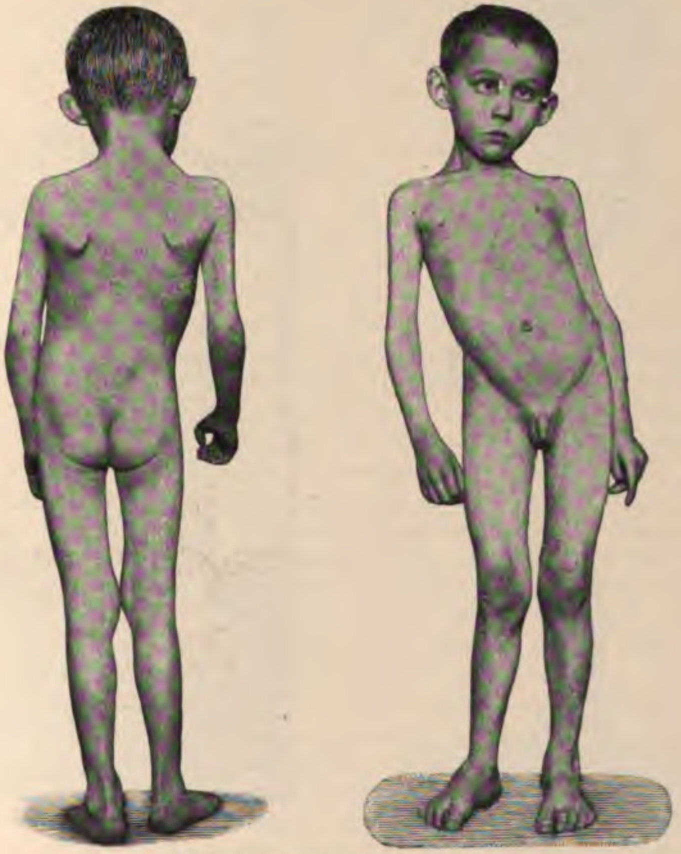


Kyphosis and scoliosis of spine.

It becomes more distinct on flexion and flattens somewhat upon extension—*i. e.*, when the patient is lifted by the arms or head. It disappears entirely only in the beginning of the disease. In rare cases the deformity may appear suddenly. The bony traberculæ left by the tuberculous process cave in suddenly in one or several vertebræ, usually following a blow or a fall or some slight trauma. For the purpose of measuring the deformity a strip of block tin may be used, which is applied closely to the back A tracing is then taken of the back. E. B. Young's (Boston, Mass.) spine-tracer, consisting of a series of vertical wooden pins that can be held in place by a horizontal frame and screw, is far more accurate.

It has already been mentioned that tuberculous disease usually produces pure anteroposterior deformity, although in advanced cases there may be some lateral deformity owing to more marked involvement of one-half of a vertebra. (Fig. 271.) Sometimes scoliosis may be present early in the disease at a time when the deviation cannot be explained by the amount of destruction in the vertebra. In these cases it must be assumed that the deformity is due to muscular contraction, especially since it is possible, at least in the early stages, to reduce this deformity by manipulation. (Figs. 272–275.) This type of deformity usually disappears under appropriate treatment as rapidly as it appeared. (Badin.)

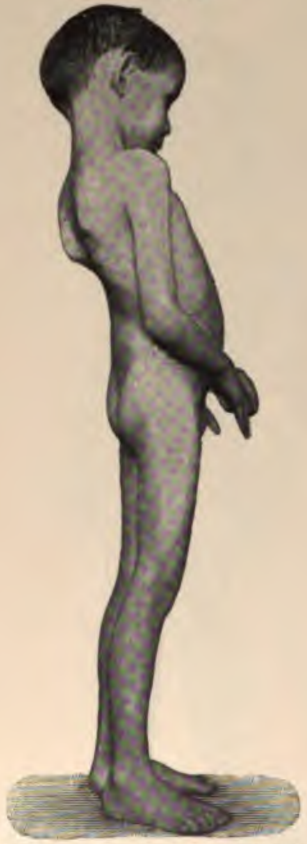
FIG. 272. FIG. 273.



Kyphosis and scoliosis in spondylitis.

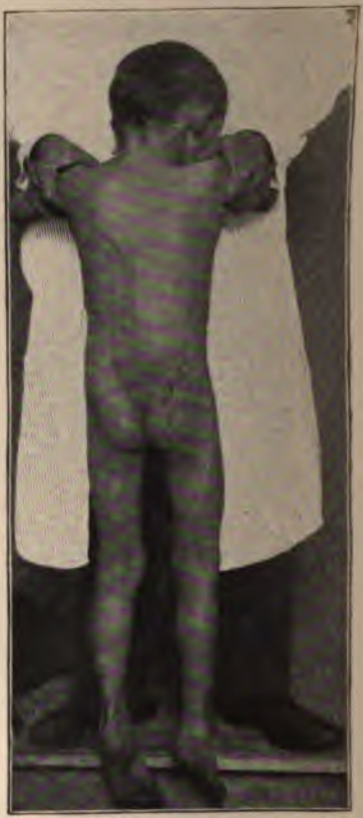
When the patients are able to sit or stand up, compensatory curves develop hand in hand with the primary deformity. The shape of the curves is modified by muscular contraction, which serves the purpose, as has been mentioned, of immobilizing the diseased portion of the spine as thoroughly as possible. Flexion is a motion which presses the vertebral bodies nearer together and is anxiously avoided by the patient, whereas extension of the upper portion of the body, which has a tendency to separate the vertebral bodies, diminishes the pressure upon the diseased portion. For this reason the patients have a tendency to increase the amount of lordosis, and not only maintain the centre of gravity in the normal position, but also endeavor to displace the same farther backward. This position is depicted in Fig. 274. The marked lordosis in the upper cervical region and the posterior position of the head may completely mask any deformity in this region, which appears only when the head is flexed. Lateral flexion usually appears as a deformity with a small radius. This type is compensated for by corresponding scoliosis, so as so prevent the body of

FIG. 274.



Kyphosis and scoliosis in spondylitis.

FIG. 275.

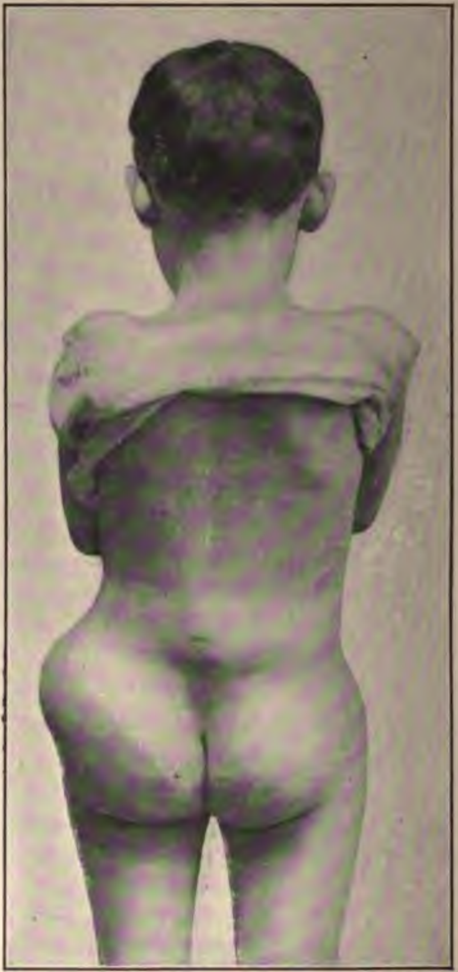


Same patient as Figs. 272–274, extended.

the vertebræ caving in on the side toward the disease. The scoliosis affects chiefly the movable portions of the column, so that in disease of the dorsal region the lumbar column and the affected portion of the dorsal region with the entire trunk is displaced toward the primary convexity. Lateral flexion in the cervical portion presents a very characteristic picture of osseous torticollis. It has already been mentioned that deformity may develop in several portions of the spine at the same time. Even when there is no posterior bony prominence, abscesses and inflammatory infiltration in the soft parts surrounding the spine may produce a prominence in this region. Any bony deformity that is present is apparently increased in this manner. Inflammatory œdema of this sort is most frequently observed in the cervical region, but may be very distinct lower down. In about 24 per cent. of the cases suppuration is clinically evident. In adults, in whom the deformity does not appear for a long time, the abscess may be present long before bony changes become evident. Not infrequently suppuration manifests itself at a time when it cannot be located by the general condition. The patients look sick, emaciate, and have afternoon temperature. The abscess develops slowly, and a painless fluctuating tumor may persist for months without increasing in size. Finally reddening of the skin and perforation take place. In rare cases the course is much more acute. Abscesses in the cervical region, when retropharyngeal, may be inspected directly or attract attention on account of the difficulty in swallowing and breathing produced. Suppuration taking place in the lateral region of the neck becomes evident from the swelling and from symptoms due to irritation of the brachial plexus such as neuralgia, or rarely paresis.

Abscesses of the lower vertebræ appear near the seat of origin only when they develop toward the back. They may then be detected as symmetrical hemispherical swellings at either side of the median line. The contents of one may sometimes be pressed into the cavity of the opposite side. Suppuration, which follows down the large vessels, usually points below or above Poupart's ligament. In the latter case the pus can be detected on palpation, percussion, or inspection. When the abscess is of considerable size, the swelling is distinctly visible; but even beforehand it may be recognized by the fact that the abdominal wall in the vicinity does not perform the normal respiratory excursions. (Albert.) The symptoms of psoas abscess depend upon shortening of the muscle due to irritation and later to reflex contraction of the flexors of the hip, thus relaxing the psoas. Flexion may be pronounced long before the presence of pus becomes evident. Flexion can be increased without resistance. Adduction, abduction, and rotation may be possible, although any attempt to diminish flexion produces pain. The apparent compensation of flexion by lordosis of the lumbar vertebræ, as in hip disease, is usually not present in psoas abscesses because the corresponding mobility of the diseased vertebræ is interfered with. Involvement of the psoas is not necessarily combined with contraction. Two cases have been reported in Breslau in which the muscle was entirely disintegrated without flexion being present during life. Later, the abscess can usually be felt in the iliac region or in the thigh. (Fig. 276.) When seen in the latter position the pus may be pressed back into the pelvis not infrequently, and in suitable cases palpation may show the presence of a swelling above Poupart's ligament at this time or an increase in the size of a tumor already existant.

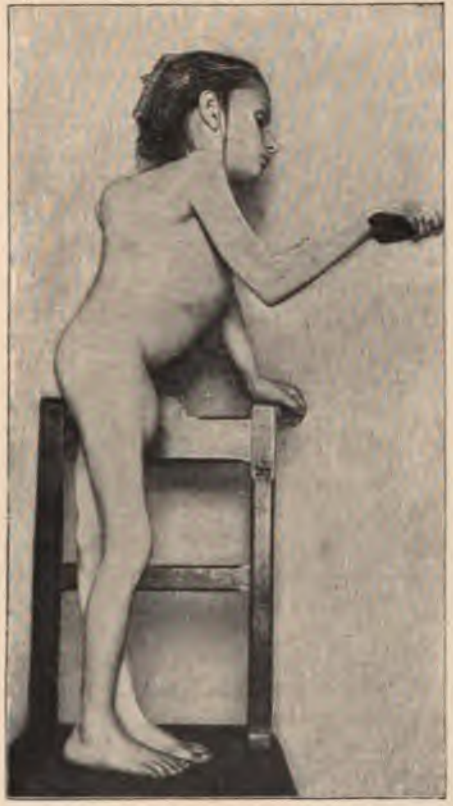
FIG. 276.



Pott's disease of lumbar vertebræ with cold absess.

The nerve symptoms may be due to pressure upon the cord, on the nerve-roots, or on the nerve-plexuses. The latter are apt to be affected by cold abscesses. In rare cases, especially in adults, the initial symptoms may be those referable to the cord, and it is not uncommon to have the early symptoms referred to the nerves. Neuralgic pain in the extremities and in the chest, and girdle pain, have been repeatedly observed. The process in the cord begins as a rule with a sense of weakness, frequently with spastic symptoms that may continue for weeks or months. The paralysis may develop very slowly, or, as is more frequently the case, increases suddenly at intervals and shows marked periods of remission. Very rarely paraplegia may follow some slight trauma. The author has already mentioned that in caries the root symptoms are usually transitory, and are apt to disappear rapidly with rest in bed and forced quiet.

FIG. 277.



Psoas abscess.

When the above-mentioned symptoms are well pronounced, the diagnosis is not difficult. Local pain, deformity, suppuration, and cord symptoms should always lead one to suspect tuberculous disease of the vertebræ, after eliminating the cases of acute osteomyelitis that run a stormy course. Not infrequently certain groups of symptoms may be absent, or at least so slightly pronounced that they cannot be shown to be present except after the most careful examination. The author has already mentioned the methods justifiable for determining local tenderness. Immobilization of the spine should be determined by asking the stripped patient to bend forward after placing the hand over the suspicious portion of the spine. One will detect immediately whether the spinous processes in this region become separated or not. Flexion is the position most suited for detecting a beginning deformity. Many patients, however, are unable to bend forward; a factor which is of valuable diagnostic import, especially when there is present a rigid position combined with the characteristic manner of picking up objects from the floor. In young children the general symptoms should be carefully considered, such as change of disposition and crying when touched or moved about, as well as the resistance offered to sitting up or walking about.

Cold abscesses should be sought for where they are most liable to appear—*i. e.*, in the pharynx, in the lateral region of the neck, in the back, the abdomen, and the thigh. Abscesses of the true pelvis may be detected by rectum. Suppuration in the iliac fossa is difficult to feel when the patients hold themselves rigid. The hips and knees should be flexed and the patients told to breathe quietly through the mouth. In children that cry one should utilize the moment of inspiration to depress the abdominal parietes quickly with the hand held in position. Sometimes the condition is made more evident by comparing the right and left side, although it should be remembered that the abscess may be bilateral. A general anæsthetic for the purpose of palpation or for rectal examination will be indicated only in rare cases. Large abscesses may usually be detected on inspection and percussion. In psoas abscesses, the psoas contraction, which may be increased but not overcome, enables an early diagnosis. When the amount of contraction is slight, it is best to place the patient face down and compare the amount of extension possible on both sides.

The difficulty in making an early diagnosis is due to the fact that most of the symptoms may be absent, and many cases are reported in which characteristic phenomena have never been present. There may be no kyphosis, which is the case in about two-fifths of the adult patients. Pain may be absent, and children, especially those not under careful observation, may play about until a pronounced kyphosis indicates the disease. Suppuration cannot be detected clinically in about three-fourths of the cases, and cord symptoms are present in only about one-eighth of the cases. Besides, the disease may be complicated with other conditions.

As far as the local pain is concerned, the differential diagnosis must consider the pain of early scoliosis and the so-called "growing pain" occurring especially in the spines of young girls. There is no fixation of the spine in either case, and the symptoms usually disappear with proper gymnastics, which, on the other hand, has an unfavorable effect on tuberculosis of the spine. Hysterical pain (neuralgia sternalis, Brodie) will be found in association with other hysterical symptoms. The kyphosis may be distinguished from other curvatures by the rigidity. The deformity in rhachitis, which may be painful in certain cases, disappears when the patient is placed face downward and lifted by the legs and becomes the complementary condition. The whole trunk becomes convexed posteriorly. A kyphosis due to tuberculosis persists under these conditions. The entire thorax retains its rigid condition and no change in the deformity is noted. The lateral displacement sometimes present and produced by muscular contraction might lead one to suspect curvature of the spine. The local pain, the rapid appearance or disappearance of the deformity in the horizontal position, will point to Pott's disease. Lateral displacement of the entire trunk is characteristic of a local process, whereas in curvature of the spine there is almost always a certain amount of rotation. The effect of exercises will frequently aid in making a correct diagnosis.

The author has referred to the difficulty in making a differential diagnosis between tuberculous and traumatic spondylitis. The trauma itself is not sufficiently characteristic, for it may be the cause of caries. Tuberculous disease of other organs and cold abscesses would be in favor of a tuberculous origin, whereas extreme local tenderness is more apt to indicate a traumatic process. The author will consider later several other local conditions of the spine that may occasionally give rise to a kyphosis (syphilis and tumors). Acute osteomyelitis is far more likely than tuberculosis to run a stormy course.

Diagnosis.—The differential diagnosis between contraction of the hip due to psoas disease and that due to hip disease is usually easy. In disease of the joint all the motions are limited, while in psoas contraction only extension is affected. The contraction in hip disease is usually a combination of flexion, rotation, and abduction or adduction. When the psoas muscle is shortened, flexion alone results. Flexion in hip disease is more or less compensated for by lumbar lordosis, which is not possible with lumbar caries. In hip disease there are also symptoms present that point exclusively to disease of the bone in the region of the hip-joint, such as shortening of the leg and a high position of the trochanter, etc.

The symptoms of Pott's disease usually develop slowly and the course of the condition is essentially chronic. According to Hoffa, at least a year and a half and usually one and one-half to two years or longer ensue before recovery takes place or death results.

It is not only possible to have the lesion in the spine itself heal, but also a series of complications may terminate favorably. As far as the local process is concerned, the tuberculous granulations may be replaced by ordinary granulation- and later by scar-tissue. The defect in the bone is largely overcome by collapse of the spine, which brings the normal bones in contact. Synostosis of these bones sometimes results. Even after the tuberculous process has ceased collapse of the spine may continue and the deformity may thereby be increased. (Bely.)

The amount of new bone formed may in certain cases be very great and the anterior longitudinal ligaments may become ossified quite early. In rare cases the region of the spine behind the bodies may become united by ossifying processes (Shaw) and prevent the formation of any kyphosis. In the vast majority of cases the amount of new bone formed is not sufficient to replace the amount lost. Not infrequently recovery is only apparent, for sequestra or cheesy foci become surrounded by healthy granulations or dense fibrous membranes and are temporarily inert. It has, however, been definitely demonstrated that virulent tubercle bacilli may be present in these foci for years, and cause a recurrence of the condition.

Cold abscesses may heal spontaneously, or may at least disappear. It has frequently been observed that distinct suppuration, which for some reason for other had not been tapped, may disappear and perhaps never reappear. Before becoming absorbed, the contents of the abscess not infrequently become serous—*i. e.*, instead of the ordinary cheesy pus there is a clear yellow syrup-like fluid which may contain cholesterin and perhaps a little sediment of cheesy material. In other cases the pus ruptures externally or into some hollow viscus in the interior of the body. Rupture of a retropharyngeal abscess may be followed by death from suffocation, and there is always the danger that internal organs, for instance the lungs, may be flooded with the pus. Only in exceptional cases is the rupture of pus the beginning of a spontaneous cure, although it is not impossible for recovery to take place in this way. In these cases the sinus closes after a varying length of time and remains closed. As a rule this is only temporarily; the pus repeatedly reaccumulates and the abscess ruptures. In the majority of cases a permanent fistula develops which becomes secondarily infected with other pus-producing organisms. The absorption taking place from the large abscess cavity and the impairment of nutrition rapidly drag the patients down so that they eventually die of sepsis or amyloid disease.

The author has already considered the subject of paralysis in connection with compression of the cord, and stated that the prognosis is relatively favorable, and that recovery may take place even after years. In many cases the paralysis is the indirect cause of death, because of complications, such as cystitis, pyelitis, or decubitus.

Besides the condition in the spine and the direct complications, there are many other dangers that menace patients with Pott's disease. Many of these individuals die of tuberculosis elsewhere, such as pulmonary tuberculosis or meningitis. The deformity of the chest and the secondary disturbances of respiration and of circulation are constant dangers.

Prognosis.—The prognosis of Pott's disease is rather unfavorable. The mortality is high and the number of actual recoveries is very small. The majority of statistics do not give any correct idea of the subject, because the observations cover too short a period. Vulpius estimated that the mortality was 34.6 per cent. if those cases were included that came for treatment five years previous to the date of tabulating the results. If only those were considered that had been under observation for two years, the death-rate was 15.4 per cent. This explains in part the differences in different statistics. The prognosis of Pott's disease, as in tuberculosis elsewhere, depends largely upon the age of the patient, and is worse with progressing years. It is questionable whether recovery ever takes place in the fourth decade. Even patients in the first two years of life frequently die of Pott's disease. Nevertheless the prognosis in children is much better than in adults. It is difficult indeed to determine the percentage of permanent cures, especially with regard to the possibility of late recurrences. Mohr's statistics, which show 44 permanent cures in 72 cases—*i. e.*, 60 per cent.—are much too favorable. The statistics of Billroth's, showing 46 per cent. mortality, 9.8 per cent. unimproved (probably died), 32 per cent. recovery, and 13 per cent. in which recovery was doubtful, are probably nearer the truth. To be sure, these statistics were taken in the year 1869, and since then antiseptic treatment and iodoform treatment have produced a certain amount of improvement, at least as far as the treatment of cold abscesses is concerned. These are not looked upon so unfavorably as formerly, when the presence of pus was considered to decide the fate of the patient. Involvement of the cord makes the prognosis materially worse. The paralysis itself, according to Vulpius, may disappear in about half of the cases. This does not, however, indicate that the final result of the primary condition will be favorable.

SPONDYLARTHRITIS.

Inflammation of the lateral joints is sometimes observed after acute infectious diseases, such as scarlet fever, diphtheria, whooping-cough, etc. Bonnet is of the opinion that the lumbago sometimes developing in the course of acute articular rheumatism is really a spondylarthritis. Witzel reports a series of observations in which acute inflammation of the cervical joints followed diphtheria and scarlet fever; and Lannelongue reports a case of acute articular rheumatism of the cervical vertebræ. Arthritis of this sort appears as an acute febrile disease with wryneck, which is produced by the attempt of the patient to remove weight from the painful joints. There are marked abduction and slight rotation to the healthy side (inflammatory wryneck). Witzel considers that the disease is far more common than generally supposed, but that it is ordinarily overlooked because it is apt to disappear rapidly.

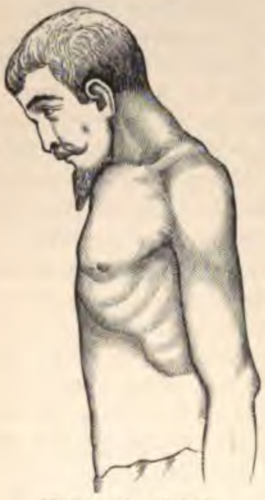
Etiology.—The etiology of cases of this sort is in all probability the same as that of the original disease which produces the lesion in the spine. On the other hand, it is well known that tuberculosis frequently develops after acute inflammatory diseases, such as measles, scarlet fever, etc. The reverse is also true. Cases of tuberculosis of the lateral joints have been reported by Witzel and Volkmann. The condition appeared in the cervical region; there was sensitiveness to pressure, with swelling in the region of the affected joints, abduction and rotation to the healthy side. Abduction was so marked that the shoulder and head almost touched. Slight motion and pressure on the spinous process were painless, although increased motion and pressure on the head produced sharp pain in the region of the affected joints. The lymph-glands were sometimes swollen, or infiltrations and abscesses developed that finally ruptured in the side of the neck. If this process heals, the convexity of the deformity is toward the diseased side. The ankylosis and the absence of rotation and scars distinguish caput obstipum ossium from muscular wryneck.

The only joints in which tuberculous arthritis is likely to develop are that between the atlas and the axis and that between the atlas and the occipital bone. Lannelongue has collected 37 cases. The patients were of greatly differing age—17 were between the fifteenth and twenty-fifth year of life. Males were twice as frequently affected as females.

In all probability the disease starts in both upper vertebræ, in the bone itself or in the occipital bone. If the peculiar shape of these vertebræ and their relations to the large joints in the vicinity are remembered, it will be evident that these articulations might easily become infected from foci in the bone. Caries of the axis will involve very early the lateral joints that are placed over the body, and from disease of the odontoid process to disease of the joints in this vicinity is a very small step. These joints may also be involved secondarily to foci in the anterior arches of the atlas. Teissier described a primary tuberculosis of the synovial membrane of these joints with secondary involvement of the bone.

All of these processes show marked tendency to extend from one bone to another and to involve the joints successively. The bones undergo caseous softening and the capsules of the joints and the ligaments become disintegrated. The anterior arch of the atlas, the lateral masses of this vertebra, the odontoid process and the superior articular surfaces of the second vertebra may disappear entirely or be found on autopsy as caseous sequestra. Occasionally a focus at the base of the odontoid process separates this from the body. In rare cases the result of the destruction is only depression of the head (Fig. 278), especially if the lateral portions of the diseased vertebræ have been subject to an equal amount of damage. Dislocations analogous to those produced by injuries are usually present. Disintegration of the ligaments may be followed by dislocations and destruction of the bone by spontaneous fractures. As a rule the destruction is greatest in the anterior portion of a vertebra, so that an inclined plane results which favors forward displacement.

FIG. 278.



Malum suboccipitale.

Spontaneous dislocation of the skull is rare. Lannelongue reports this condition 3 times in 32 cases, and mentions 27 cases of dislocation of the atlas and 2 in which the skull with the atlas was misplaced. Those cases are included in the 27 in which the broken-off odontoid process was displaced forward with the arch of the atlas. Dislocation pure and simple is possible only when the transverse ligament is destroyed.

When the destruction is entirely or chiefly on one side, the dislocation is also unilateral. Even when the bone and ligaments are extensively destroyed there may be no displacement, or this may take place quite late, especially when the infiltrated muscles of the neck, that become hard as boards, act as a splint for the diseased portion.

In suboccipital disease, as in caries of the spine elsewhere, the cord may be involved in two ways: 1, by dislocation—*i. e.*, bony diminution of the lumen of the canal; and, 2, by inflammatory processes. The first condition is far more uncommon and may at times follow trauma. With dislocation of the atlas pure and simple the odontoid process bores into the cord and produces instantaneous death. Cases of this sort have been reported by Sédillot, Tillaux, and Lannelongue. Buckley reports the case of a child seven years old that allowed some foreign body to enter the trachea and had been gently patted on the back by another child. The child dropped dead immediately, and the autopsy showed that the odontoid process had broken off close to its base and had become dislocated toward the cord.

Generally speaking, it is more favorable to have the odontoid process break off with the dislocation, as has been seen in connection with traumatic dislocation and fracture. The cord may escape pressure from the odontoid process in pathological dislocation when this bone has become completely softened, or when the displacement is not strictly anteroposterior, but anterolateral, thus allowing the process to slip past the cord to one side.

In suboccipital disease the cord is liable to be involved by a peripachymeningitis and secondary œdema. The disease of the dura frequently extends far into the interior of the skull and involves the region of the clivus Blumenbachii and the medulla oblongata.

Abscesses developing in the upper region of the vertebræ follow various courses. Sometimes they extend toward the vertebral canal or develop along the anterior and posterior surface of the vertebra. The pus burrows backward from the lateral joints into the connective tissue between the short deep muscles of the neck. When the lesion is unilateral, the head is inclined to the diseased side so as to relax these muscles. There is also a slight amount of flexion. In bilateral disease the head is rigidly held straight forward. When the chin is turned toward the right early, it is justifiable, according to v. Bergmann, to conclude that there is a beginning focus in the atlo-occipital joint of the same side.

The pus extends from the deeper to the more superficial muscles, and appears at the side of the splenius and trachelomastoid. A swelling which is frequently confounded with an osteosarcoma appears beneath the occiput and first presents a fluctuating point just behind the mastoid process. When the abscess is anterior, the pus collects first in the transverse space found below the anterior margin of the foramen magnum. The pus then extends downward between the longus capitis and rectus capitis anticus minor into the retropharyngeal connective tissue. As a rule these abscesses do not dissect farther downward because they are more apt to rupture early into the pharynx. In a case reported by v. Bergmann the pus extended along the base of the skull as far as the foramen lacerum, and reached the brain through this opening, causing thrombosis of the transverse sinus.

Symptoms.—The symptoms that first attract attention are those of nervous origin, because they are the ones that control the clinical picture. There may be severe neuralgia in the region of the upper cervical nerves—*i. e.*, of the occipitalis major and minor and auricularis magnus. Patients frequently suffer from violent pain in the back of the head, the external ear, the parotid region, and especially in the middle of the nape of the neck, where they oftentimes feel as if stuck with the point of a knife. At times there may be pain in the lateral region of the larynx, in the shoulders and teeth; the reason for this is not known.

The function of the hypoglossal nerve may be interfered with; there may be difficulty in moving the tongue and swallowing or atrophic paralysis of one-half of the tongue. (Vulpius.) Sometimes there are optic symptoms, such as twitching of the lids, nystagmus, or inequality of the pupils. These are also difficult to explain. The pain is much increased by pressure over the spinous process of the axis, and may be so severe as to mask the ordinary sensitiveness to touch noticed when palpating the bodies through the mouth.

The first sign of disease is as a rule a peculiar stiff position of the head produced by relaxation of the deep muscles, for the purpose of avoiding the pain that is associated with motion of the affected joints. When the focus is unilateral, the head is slightly flexed and turned toward the affected side. In bilateral disease the head is inclined straight forward. Motion is avoided, including the nodding. When looking to one side, only the eyes or the entire body turn. Jarring of the head produces pain, so that the patients' gait is circumspect with flexed hips and knee-joint. They support themselves upon their hands as much as possible by grasping the head either beneath the chin and occiput or on either side.

When the symptoms are as marked as this there is usually swelling due to retrovertebral or prevertebral infiltration or suppuration. The swelling may appear in the fossa at either side of the nape of the neck and extend on both sides as far as the mastoid processes. Angina hippocratis is characterized by difficulty in swallowing and breathing. When these symptoms diminish, it is fair to presume that the abscess has ruptured into the pharynx. If the seat of perforation is small, the pus may escape slowly and the patient may expectorate small quantities of pus for a long time. In other cases a sudden gush of pus may flood the region of the larynx and cause suffocation.

Another symptom resulting from extensive destruction of bone is shortening of the neck, which may be bilateral or more pronounced on one side, producing a sort of torticollis. Pathological dislocation may also occur. The chin is depressed and the head is displaced forward; with unilateral dislocation there is rotation toward the side least affected. The spinous process beneath the dislocated vertebra may be very prominent. When an abscess forms, or, at the latest, when one already formed has ruptured, the neuralgic pains, so marked at first, disappear. On the other hand, the sensitiveness on motion or to direct or indirect pressure over the diseased portion increases so markedly with progressive destruction of bone and joints that even a slight jarring of the floor may be insupportable. After the abscess ruptures there is usually apparent improvement.

When deviation of the head becomes noticeable, symptoms referable to the cord usually appear. There is at first motor paresis of the arm, and the power in the hand diminishes; later the paralysis increases. Disturbances of sensation follow. The process is located above the arm-centres, so that the surgeon has to deal with a spastic paralysis. Finally the legs become involved, and last of all the bladder, the rectum, the trunk, and the diaphragm. Death takes place with symptoms of asphyxia and cardiac paralysis. As a rule the paralysis is symmetrical, although in one case the clinical picture was that of typical unilateral lesion. (Cotrel.) As a rule the paralysis develops slowly. In the course of weeks a gradual increase of symptoms is evident, associated with periods of remission and exacerbation. The cases of sudden death mentioned are exceptional.

Diagnosis.—The diagnosis is easy when the symptoms are typical. Neuralgic pains are first noted, and are followed by rigidity of the neck and dense infiltration beneath the occiput, increasing local tenderness, abscesses that first appear behind or at the side, then in the retropharyngeal region. Later the neuralgic pain diminishes and there appear signs of increasing bony deformity and cord symptoms. Not all of these symptoms need be present to enable a correct diagnosis. Even in the early stages of occipital neuralgia with a point of tenderness in the nape of the neck beneath the occiput suboccipital disease should be suspected, and with the typical position of the head or with swelling there can be no doubt. The swelling may, to be sure, sometimes be due to periosteal sarcoma at the base of the skull.

The differential diagnosis between traumatic fractures or dislocations is readily made in the early stages, but in old cases in which the history has been forgotten there may be difficulty. Certain pathological dislocations have no doubt been considered to be spontaneous fractures or the results of trauma. Thick fibrous scars and callus around the deformed portion of the vertebral column should lead to suspicion of old tuberculosis.

Prognosis.—The prognosis in suboccipital disease is much worse than in tuberculosis in other regions of the vertebral region. The succession of symptoms is much more rapid and the disease progresses much more rapidly. In one of Teissier's cases the patient died twelve weeks after the first symptoms appeared. In rare cases the symptoms may last for one or two years, and sometimes the patients recover even after there has been considerable destruction of bone with or without marked cord symptoms. The slower these develop, the greater the possibility that the process may remain stationary or subside; on the other hand, rapid progression of symptoms is unfavorable.

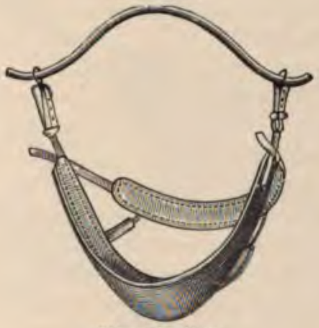
The lumen of the canal may be considerably diminished without permanent damage to the cord, as shown by numerous autopsies. Paralysis or pareses may continue throughout life. The bony lesion usually heals with synostosis of the bones that become approximated. Ankylosis between the occipital bone and the axis has been observed after a considerable portion of the atlas had been cast off.

Treatment.—The treatment of spinal tuberculosis consists almost entirely in preserving the strength of the patient and placing the tissues in such a condition as to be able to overcome the infection. Of aid are general treatment and diet; local measures, such as rest in bed and removal of superincumbent weight, all of which protect the tissues around the focus and increase their power of resistance. This treatment also diminishes the chances of spreading the tuberculous virus by crushing the tissues containing the bacilli. The use of iodoform should be mentioned in this connection, for this drug acts favorably upon granulations and favors cicatrization. Aside from this indirect treatment direct measures may be employed, such as operative elimination of the focus of disease. Sometimes certain symptoms of the disease may be met, especially deformity or nerve disturbances, even when the tuberculous process proper has completely healed. The appetite should be stimulated, abundant exercise should be taken, and if possible open-air living, salt baths or sea baths should be directed. Patients that can be moved should if possible be sent to appropriate resorts where they may lie prostrate protected from the wind and yet be in the open air. In southern countries this treatment may be carried out during the winter. Living out in the open air in itself has a favorable influence. One should exercise considerable care in using salt baths. Motion of the diseased column that easily takes place in the bath may be avoided either by appropriate apparatus worn in the water or by stretching a piece of canvas horizontally in the tub, upon which the patient may lie flat. If carelessly given, the patients become nervous, tired, and run down rather than improved. It is best to dilute the brine and shorten the bath to about five minutes, and have the temperature about 35° C. At first the bath should be given not oftener than every second or third day. The patient's weight should be accurately controlled and the strength, duration, and frequency of the baths correspondingly increased. Local packs may be used in the form of poultices of strong brine that are left on over-night. The object of this treatment is to increase the appetite, a result that soon becomes evident if sufficient care is used. It is best to give small meals at frequent intervals and allow milk or kumyss between.

The results of treatment, which should last not less than two months, are best in some sanitarium or "Kurort." Under unfavorable conditions improvement is only too apt to give way to serious relapses. The brine baths have been replaced by soap treatment by Kollmann, Diruf, Gisler, and Hoffa. Sapo kalinus venalis transparens is best, and should be rubbed in two or three times a week. About 5 to 10 ounces may be rubbed in with the hand or a sponge on the back or thigh. If the patients are wearing a corset or jacket, this should be put on immediately afterward. After about half an hour the soap is washed off with a sponge and warm water. The patient should lie down for a short time after the rubbing in, so that it is best to treat ambulatory patients in the evening. This soap treatment is said to increase the appetite materially.

Little is known regarding the effectiveness of subcutaneous injections of iodine recommended by Durante, or of the subcutaneous use of guaiacol and iodine as recommended by Frassi. At the present time it is believed that tuberculin is useless. Active out-of-door life is without doubt much more valuable than rest in bed, and patients with tuberculosis of the spine should always be put upon their feet as soon as possible. There is no doubt that this method of treatment has been carried too far, and it has been overlooked that any applied apparatus is never able to immobilize the region as effectively as bed treatment. König has called attention to the fact that the general condition of a patient may be completely restored in bed provided the local focus has healed. When, on the other hand, the local condition becomes worse, even the best climatic surroundings and apparatus do not prevent the general condition from becoming much worse. The majority of surgeons keep fulminating cases in bed and use ambulatory measures during convalescence. The weight is removed from the spine in the act of lying down, although not completely. When the regions of the spine that are normally convex anteriorly, such as the neck and lumbar regions, adapt themselves to the bed, it means that motion takes place tending to produce kyphosis, and that the bodies of

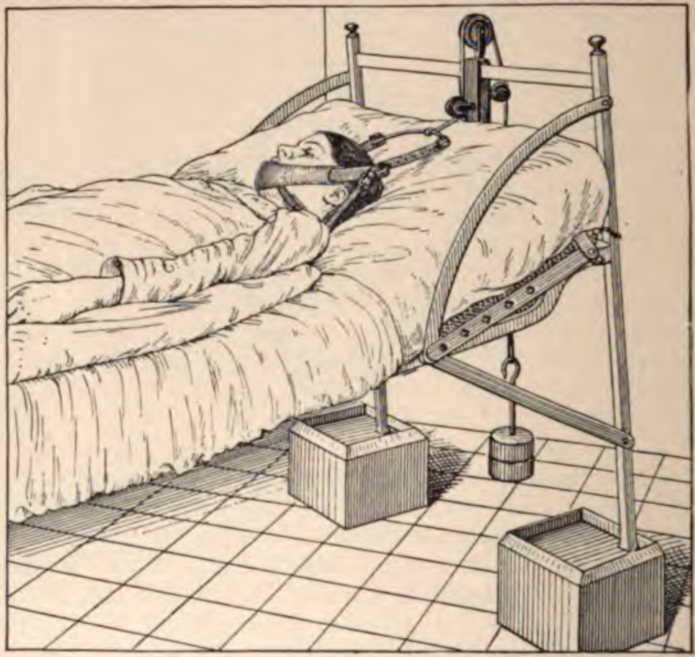
FIG. 279.



Glisson's sling.

the vertebræ are pressed more closely together, which is exactly what should be avoided. The dorsal vertebræ might possibly become somewhat extended, although the mattress is far more liable to adapt itself to the spine than the spine to the mattress. Certain of these disadvantages might be overcome by placing the patient face downward, but for obvious reasons this cannot be done for any considerable length of time. There are two ways of removing the weight from the bodies of the vertebræ—traction and overextension. Both of these methods may be combined. The traction method is applied chiefly in cervical diseases and in disease of the upper vertebræ by means of Glisson's sling. (Fig. 279.) Counterextension is furnished by the weight of the body, the effect of which is increased by raising the head of the bed. Extension may also be used in lumbar disease, when the traction will be applied to the legs. In the clinic at Breslau it is customary to use plaster-of-Paris splints and suspend them on an overhead trolley. Traction is furnished by means of an extension apparatus over the foot of the bed. The mattress reaches only to the edge of the pelvis, so that the legs are free. (Fig. 280.) Friction is avoided in this way and counterextension is obtained by raising the foot of the bed. When the middorsal region is involved, traction applied to the head or to the legs is of no avail. Overextension in

Fig. 280.



Extension of head by means of Glisson's sling.

bed by placing pillows beneath the affected region is the only effective method. Rauchfuss' swing, which serves the same purpose, is of value in this connection.

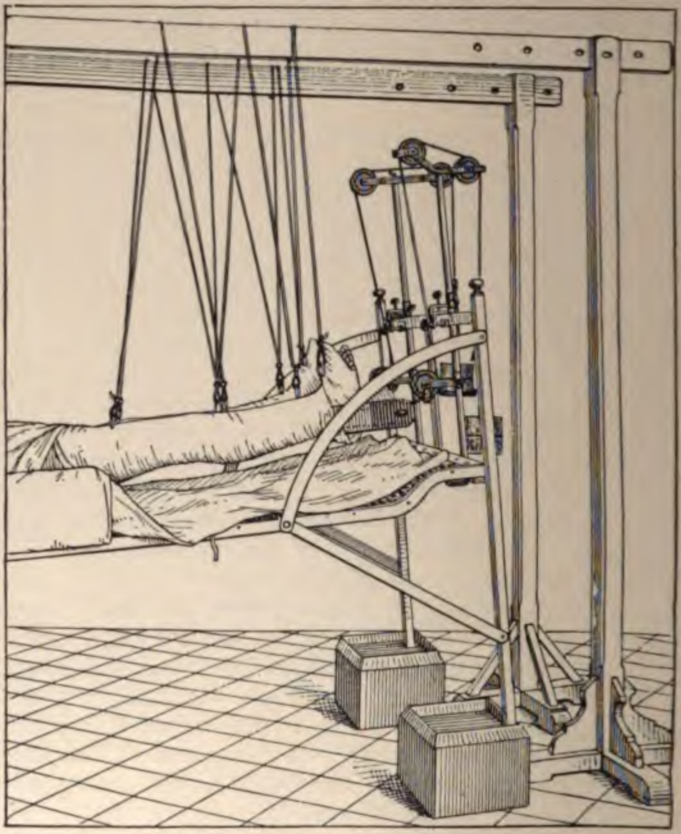
The apparatus above mentioned removes the weight from the bodies of the vertebræ, but does not immobilize the spine completely. Every movement of the bowels, etc., necessitates a change of position and readjustment of the apparatus. The latter is so cumbersome that the patient is more or less confined to one place, and it is hardly ever possible to have him taken into the open air regularly. Phelps' standing bed places the patient at rest and renders him easily transportable. This apparatus, however, has the disadvantages that overextension is not possible, and that the overlying weight cannot be completely removed when the disease is high up or some extension apparatus can be added.

Lorenz's plaster-of-Paris cast immobilizes the spine and removes the superincumbent weight, and has the advantage that it can be made at any time. The patient is placed in such a position that his spine is overextended. This may be done easily by placing pillows beneath the body. The amount of overextension will depend upon the thickness of the underlying pillows. The disadvantage of these pillows, especially with restless children, is that they become easily displaced, and that in adults they must be extremely thick, if the necessary amount of overextension is to be obtained. Several sorts of apparatus have been constructed that tend to diminish these disadvantages. Lorenz made use of an inclined plane that could be placed at any angle; and the bed constructed by Redard serves the same purpose. The pillow for the thigh is partly replaced by an inclined plane and partly by a head-rest. In the Breslau clinic the plaster-of-Paris apparatus is usually applied with the aid of Nebel's swing.

Nebel's apparatus consists of a rectangular frame of gas-pipe, 2 m. long and 60 cm. broad. A smaller frame is attached at one end, as shown in Fig. 281. The angle of the inclined plane may be regulated by placing blocks under the end of the frame, which touches the floor. The patient is supported upon the inclined plane by three or four supporting bands, one of which is placed beneath the upper end of the sternum, the second beneath the pelvis, and a third beneath the thighs a little above the knees. The fourth may be placed beneath the legs, and serves the purpose of immobilizing the latter. The head rests either upon a supporting apparatus or is fastened to the upper end of the inclined plane by means of Glisson's sling. The amount of overextension can be regulated by means of a longitudinal strap connecting the two narrow ends of the frame. This passes over the transverse strap that supports the shoulders and pelvis. The more slack this latter strap, the less the support to the trunk. Small transverse rods are attached to the rectangular frame beneath the upper end of the inclined frame, and serve the purpose of furnishing some support for the hands of the patient. The spine does not overextend immediately, but gradually, and may be aided by slight pressure with the hands.

The amount of overextension must not be excessive, because if so the traction on the anterior portion of the vertebral bodies will cause pain. For this reason it is best to let the patient judge for himself which position is the most comfortable. While in this position the back of the patient, from the crown of the head to the gluteal fold, is covered with a thin layer of bandage. This will prevent the plaster from adhering to the trunk of the patient. Over the whole a plaster-of-Paris bandage is applied. It is well to begin at the crown of the head and use a series of longitudinal folds, one in the middle and one at each side, reaching down to the gluteal fold. Another longitudinal band passes still farther out, beginning from the axilla and ending at the outer end of the gluteal fold. Five or six bandages are used in this way and the plaster well rubbed in. Over the longitudinal band there is placed a series of transverse bands and then longitudinal bands again until the apparatus is sufficiently strong. Its resistance may be farther increased by placing between the individual layers of the plaster strips

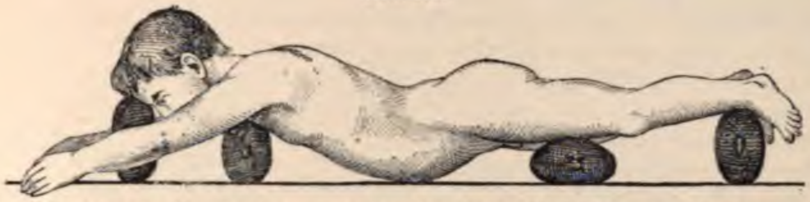
FIG. 281.



Extension of legs.

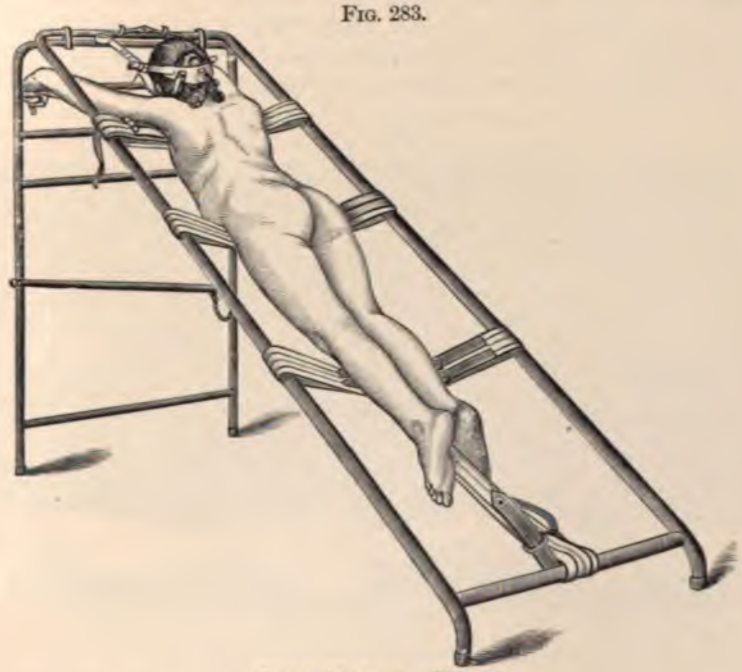
of splint-wood, 2 to 3 cm. broad, that have been heated and made pliable. These strips of splint-wood are placed longitudinally and transversely about 2 to 3 cm. one from the other. The places where the plaster is likely to break, such as the neck and along the lateral margins, may be reinforced with plaster-of-Paris and gauze. When the plaster has hardened sufficiently, it is removed and any inequalities in the interior smoothed out. It is then dried in the sun or over a stove. The corners should be rounded off and the armholes should be cut to allow of sufficient motion. The gluteal region should be also cut out and smoothed off. For the purpose of preventing the plaster becoming soaked with water, it is painted with several coats of an alcoholic solution of shellac. Certain authors modify this plaster-

FIG. 282.



Position of patient for the purpose of making plaster-of-Paris bed-cast (Lorenz.)

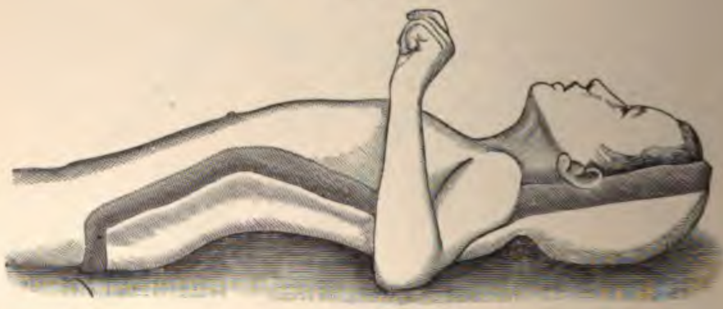
FIG. 283.



Suspension frame. (Nebel.)

of-Paris mould, because it is difficult to protect against moisture even with the coating of shellac. The mould may be partially filled with plaster-of-Paris and used as a cast of the patient, over which corsets of various material, such as wood-pulp and celluloid, may be made. Dollinger makes a mould while suspending the patient gently and then prepares a permanent mould of hammered copper, which is covered with a very thin layer of cotton or knitted material. The latter may be glued down over the margins or corners, and with young children waterproof material must be used. The cotton material is covered with a smooth piece of linen cloth, and the patient wears a shirt and is tied into the cast with circular turns of a bandage. After this he may be dressed. (Fig. 283.) During the first few days the back should be repeatedly inspected, so as to control the points of pressure, and regions where there is danger of pressure-ulcers developing should be hollowed out. Defecation and micturition are not interfered with and the anterior surface of the body may be washed at any time. For the purpose of washing the back, the patient is turned face downward and the cast removed. The only region of the spine where this form of treatment is not applicable is the cervical region. The marked over-extension in this region would be very tiresome, and for this reason Lorenz's method of combining the plaster cast with extension is best. After placing the patient so that the occiput is on the same plane with the back a plaster cast is made in the usual way. The extension apparatus consists of a jury-mast, a steel spring fastened to the cast in the median line extending beyond the upper margin of the plaster. The free end curves forward over the head and reaches about to the middle of the vertex. A transverse arm is attached here, and the head is fastened to this by means of Glisson's sling. Extension is kept up by the action of the spring. (Fig. 284.) The jury-mast is either riveted to the plaster cast or incorporated in the upper layers. The lower portion is forked and has several transverse bands, so as to be readily fastened to the plaster. (Fig. 285.) When there are contractures or painful contractions of the muscles of the lower extremities,

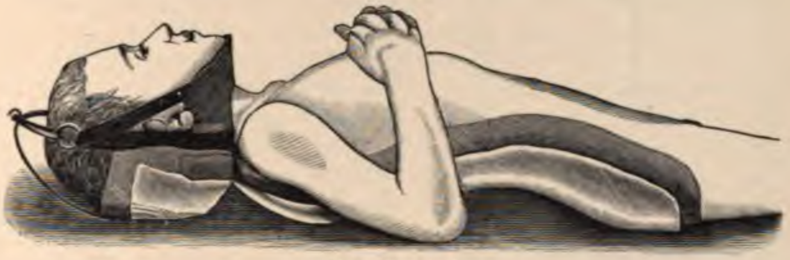
FIG. 284.



Horizontal fixation cast.

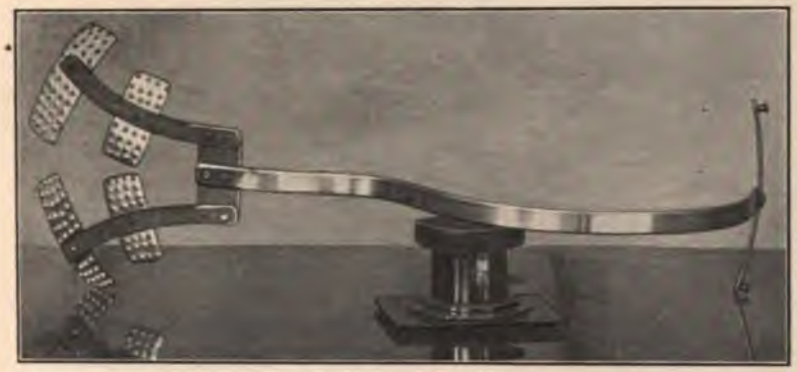
the plaster-of-Paris cast may be sufficiently lengthened to include the legs. The beneficial effect of absolute fixation obtained in this way soon becomes evident from the absolute cessation of pain as well as the improvement in the general condition. When the absence of symptoms, especially of pain and sensitiveness to pressure, seems to indicate that recovery is well under way, it is time to get the patient on his legs, and instead of the plaster-of-Paris cast, some ambulatory apparatus must be used, such as a corset. This appliance is frequently used even in the acute stage of spondylitis. The originator of this method, Sayre, believed that the plaster jacket produced complete immobilization and removed all superincumbent weight. At the present time the general opinion is that these conditions are fulfilled only to a certain degree. If the jacket is to remove the superimposed weight, it should be applied in a position in which the mutual pressure between the bodies of the vertebræ is as slight as possible. This is best done by supension or by placing the patient on his face after the method of Nebel.

FIG. 285.



Extension cast.

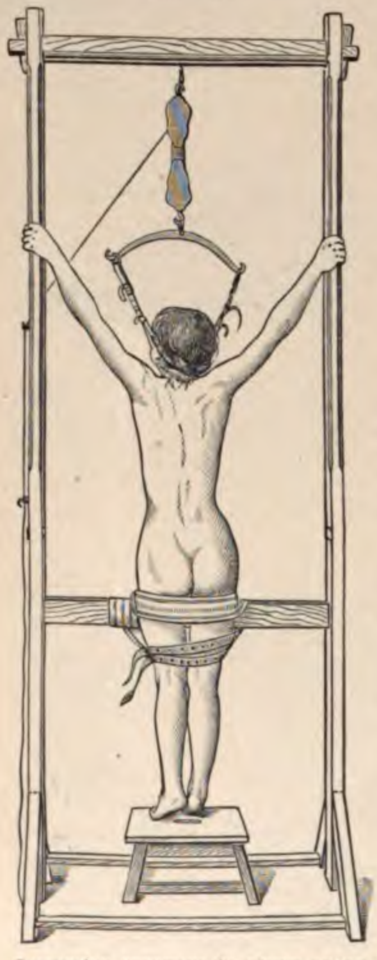
FIG. 286.



Jury mast. (Whitman.)

The method of applying extension is illustrated in Fig. 287. The head is placed in Glisson's sling and drawn upward by pulleys that are fastened to the ceiling or to Beely's frame. The latter has an arrangement for the purpose of fixing the hips. The patient should grasp the sides of the frame with the hands The patient is then suspended until he is just able to stand comfortably on his toes. The apex of the deformity and the anterior superior spines are covered with cotton which is held in place with a few turns of a bandage. A strip of thin tin 5 cm. broad, reaching from the sternal notch to the symphysis pubis, is held in place in the same manner. The plaster-of-Paris bandages should be made of fine muslin and be about 15 to 20 cm. broad. They should be softened in warm water containing a pinch of alum and squeezed out moderately. One should commence below at the level of the trochanters, and the individual turns should be applied carefully and cover each other for about two-thirds of their width. Reverses are not to be made: it is better to cut off the bandage. Each turn of the bandage should be thoroughly rubbed into the previous layer and with good material five or six layers will be quite sufficient. As soon as the plaster has set, the bandage is split along the anterior surface with a knife or scissors. The strip of tin protects the patient. The split bandage should be grasped by a hand on each side, spread apart, and pulled off sidewise. The edges should be accurately approximated so as to allow the cast to harden and retain the desired shape. It is held together by a few turns of the bandage. After it has hardened sufficiently it should be trimmed and cut out under the arms so as to be comfortable. This should also be done in the inguinal region, so as to allow the patient to sit down easily. The margins of the corset are covered with leather or flannel, and a series of hooks for the purpose of lacing are fastened on either side in front. It is best to have the patient wear a woollen tight-fitting undershirt. The corset should be put on while the patient is suspended. The author is in the habit of

FIG. 287.



Suspension apparatus for plaster-of-Paris corset.

lacing the abdominal portion with string, but in the region of the chest he uses a thin strip of rubber so as not to interfere with respiration more than is necessary.

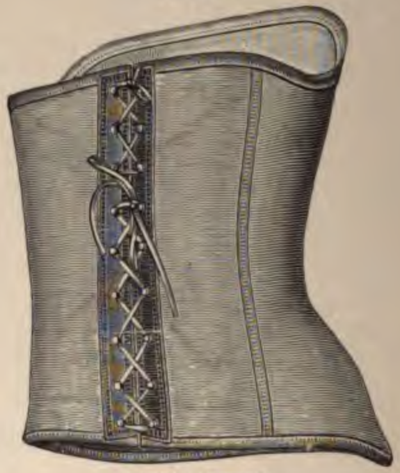
There are several disadvantages connected with plaster-of-Paris corsets. They are hygroscopic, and to be durable should be quite heavy. The plaster may be protected against moisture by covering with shellac or other waterproof material; the durability of the corset, however, is but slightly increased by these measures. A plaster-of-Paris corset may be used as a mould for a plaster-of-Paris cast of the patient, and then a corset of some other material may be made over this cast. In this way material may be used that takes considerable time to harden. Plaster-of-Paris bandages may be applied without padding the body, the points on the cast which may cause ulceration from pressure being thickened slightly with a little plaster.

Celluloid and sodium salicylate corsets are made by soaking cloth of some kind in solutions of these materials. The celluloid corsets have of late been extensively used. The solution is prepared by filling a bottle about one-fourth full with pieces of celluloid and then adding acetone. The stopper must be tight so as to prevent evaporation. The bottle should be shaken and the contents stirred until the mass is of uniform consistence and resembles thick syrup. The cast is covered with a layer of smooth bandages that are applied in such a way that they overlap about one-half of their width, and the solution of celluloid is then rubbed in with the flat of the hand. A second layer of bandage is immediately applied and saturated with the solution. This process is repeated until about eight layers have been put on. A little zinc oxide may be added to the celluloid in the outer layer so as to make the corset pure white. This corset should remain on the cast at least twenty-four hours, and is then cut and treated in the same way as a plaster cast.

In Breslau some of the bandage is replaced by knitted material, such as stockinet, of sufficient size to adapt itself closely to the cast. Plaster is very apt to stick to the inner layer of the corset, so that it is well to apply first a layer of bandage and then cover this with the knitted material, into which the solution is rubbed. The corset is completed by alternating layers of bandage and knitted material; four layers of the former and three of the latter are quite sufficient. These corsets are much more elastic than those made of bandage alone. The underlying layer of bandage can easily be peeled off, and the knitted material forms the inner lining of the corset. It is well to divide the corset on either side, for instance, in the anterior axillary line, besides the usual anterior division, and then fasten the strips of corset together with canvas. The lacing is put in as in the plaster-of-Paris jacket. (Fig. 288.) Trimming is easy if the celluloid is first bored with an awl before passing the needle or if a strong leather-sewing machine is used. Celluloid corsets can be made by any surgeon without especial apparatus, and the cost of the material is slight compared with the durability.

Leather corsets (Bingler) are made by softening the material in warm water and then applying to the cast under considerable tension. A narrow slit is left anteriorly in the median line and the margins of the leather are fastened here with tacks. The material is allowed to dry several days in a warm place and is then trimmed in the usual way. Various kinds of leather have been used, some of which necessitate the use of metal strips. These are applied to the cast underneath the leather, which is stretched over them and fastened down so tightly to the cast that it applies itself to the plaster all around the metal. These strips are let into the leather as it were, and after the corset has been removed from the cast they can be fastened in place with rivets.

FIG. 288.



Celluloid corset.

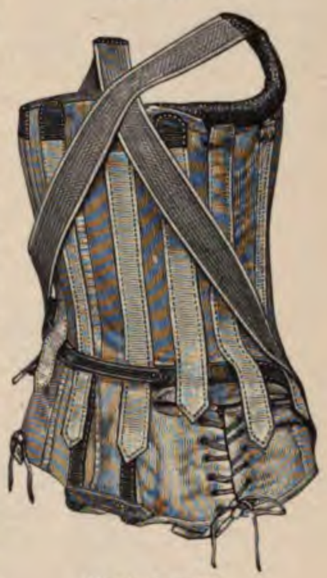
The felt corsets formerly used are of service if made over a plaster-of-Paris mould, and not over the body itself. A sheet of dry felt about 4 to 5 mm. thick is fastened over the cast and saturated with an alcoholic solution of shellac and allowed to dry. This process is repeated until the felt ceases to absorb. After about twenty-four hours the corset may be finished in the usual way. Felt corsets necessitate the use of strips of metal that are fastened in the same way as above described.

Another material used for making corsets is the glue used to cause cellulose, linen, wood, or cork to adhere. Walltuch's wood glue corsets are quite popular. Shavings 5 cm. broad and about 0.5 mm. thick are employed instead of the bandages, and are glued together with carpenters' glue. Three layers are sufficient after first covering the mould with some knitted material. All of the glue appliances have the disadvantage that moist heat is apt to soften them so that they lose their shape. They not infrequently have a disagreeable odor. This disadvantage may be overcome by adding a little potassium dichromate.

All of the corsets above described have the advantage that they can be prepared without preliminary training. Any locksmith can adjust and rivet the strips of metal, and a surgeon who has had any experience whatever in preparing orthopædic apparatus is independent of the aid of a mechanic.

It is somewhat more difficult to make one of Hessing's corsets. These are so excellent that they should always be used unless the cost is an objection. They consist of a cloth corset that is accurately fitted, and which is stiffened by strips of metal sewn into the material. The corset should lace in front and be shaped in such a way as to avoid pressure upon the breasts. This apparatus rests on the pelvis by means of two pelvic bands that reach from the anterior superior spines in front to the level of the trochanters behind. These pelvic bands support two axillary strips with crutches, the height of which can be altered. Behind at either side of the spinous processes is a strip of pliable metal that adapts itself closely to the spine. There are a number of straps to fasten the corset; two reach from the anterior ends of the crutch-pieces over the shoulder and cross in the back to be attached to the anterior end of the pelvic band on the opposite side. There are also two in front and behind that pass horizontally between the ends of the pelvic bands. Hessing's corsets are usually fitted to the body itself. Some flexible metal—*i. e.*, 2 parts of lead and 1 part of zinc—may be used as a model for the strips to be incorporated in the cloth. These corsets reach from the pelvis to the axillæ, and are of service in fixing the spine and removing weight only when the lumbar or lower dorsal vertebræ are involved. If the process is high up, the support must be made longer. Any corset may have crutch attachments similar to those of Hessing's. The arms are supported in this way and the weight of the shoulder-girdle is partly borne at least by the corset.

FIG. 289.

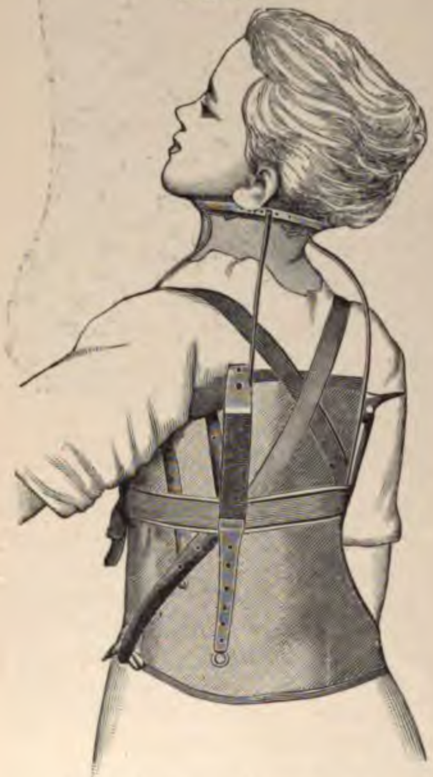


Hessing's corset.

Appliances that support the head itself are much better. Formerly it was customary to make use of Glisson's sling and a jury-mast fastened to the plaster jackets in the same way as described in connection with the plaster casts. (Figs. 285 and 286.) A jury-mast attracts notice and makes it difficult to wear a hat. The chin and occiput have been made use of as points of support, and Glisson's sling has been replaced by well-padded metal rings that fit the head accurately. They are attached to the corset in such a way that there is always elastic pressure from below upward, which tends to extend the column.

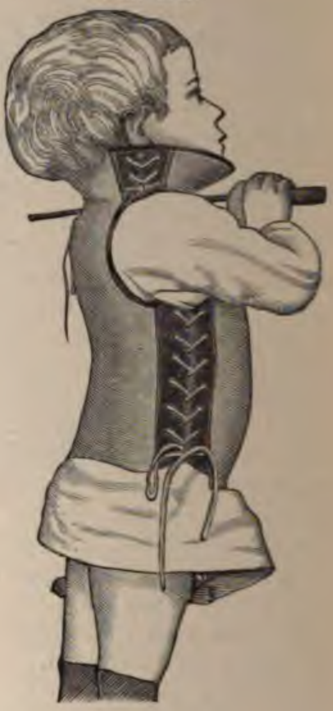
Hoffa has modified Heusner's head-support and uses a ring that is attached to the corset by four rods, two in front and two behind. These reach downward as far as the waist. Rubber bands are fastened to the lower extremity of these rods and to the upper margin of the corset. These elastic bands may be tightened and the amount of upward pressure upon the head regulated. (Fig. 290.) The appliance shown in Fig. 291 is not elastic, but immobilizes the head much better and is extensively used in the clinic in Breslau. For the purpose of preparing an apparatus of this sort the patient is suspended by means of a sling made of linen cloth, instead of Glisson's leather sling. The plaster-of-Paris bandages are carried upward around the neck and the jacket is opened on one side. This plaster jacket mould is used to form a cast over which a permanent celluloid corset is made, which is divided on both sides, so that it consists of two parts that are fastened to each other by lacings.

FIG. 290.



Celluloid corset with head-support.

FIG. 291.



Celluloid corset with collar.

There are numerous other methods of supporting weight besides those described. They consist of a pelvic band supporting two or more dorsal uprights, to which some apparatus is attached that supports the head or arms. Sometimes they are made with a spring that tends to pull the shoulders backward and extend the vertebral column. Taylor's and Schildbach's traces, which are based on this principle, will not be described in detail.

Removable corsets are for patients that are on the way to recovery. The lacing enables the individual to remove the appliance and care for his skin. It must be acknowledged, however, that immobilization is more perfect when the apparatus cannot be removed. Sayre has followed this principle and used plaster jackets in the treatment of acute caries. Of late, certain authors, such as Karewski and Calot, have returned to the use of permanent plaster-of-Paris jackets. Calot attaches great importance to combating the deformity. He extended the kyphosis forcibly by longitudinal traction and direct pressure upon the apex. This method need not be described in detail because it is dangerous and has been discarded.

A modification of Calot's method is the plaster-of-Paris corset that tends to correct the faulty position, not so much by attacking the deformity itself, as by increasing the compensatory lordosis. In the clinic at Breslau Nebel's apparatus is usually used for this purpose. Suspension with pressure from behind over the deformity serves equally well in some cases.

When the disease is high up, the author makes use of Calot's apparatus that takes in the pelvis, the trunk, and the head, and leaves only the face free. Sometimes a permanent jacket that reaches from the jugulum to the anterior superior spinous processes and does not cover the neck and shoulders will be found sufficient. The edge beneath the arm must be broad and smooth so as not to irritate the skin. It is best to include the shoulders in the corset and cut the unnecessary portion down so that the jacket may fit closely to the sternum. A window may be cut in the abdominal region after the jacket has hardened so as to relieve respiration.

Besides the bloodless methods that attempt to remove deformity there are a number of operative measures that have the same object in view. Calot's method of resecting the spine and removing a wedge-shaped piece from the body of the vertebræ with a chisel after exposing the cord for about 6 cm., will not be imitated by conscientious surgeons. The removal of a prominent spinous process is a purely palliative measure. Calot did this for the purpose of preventing ulceration of the skin over the apex of the deformity so as to avoid decubitus in a plaster-of-Paris appliance that fitted well otherwise. It has been claimed that to sacrifice the spinous processes and the ligaments and muscles between them removes one of the factors that tends to prevent further kinking of the column. Calot believes that this step, however, is justifiable, because he assumes that cicatricial contraction or bony new growth unites the arches with each other and thereby prevents the separation necessary for the development of a kyphosis. This author recommends making flaps out of the periosteum of the arches and transplanting these from one arch to the other, a suggestion first made by Hadra, who unites the spinous processes of the diseased portion of the spine with silver wire. Chipault united the arches in this way as well as the spinous processes. These silver wire sutures probably cut through in time, so that they have been replaced by some organic material. Vulpius attempted to produce a synostosis of the spinous processes by means of small flaps including bone and periosteum.

The above described methods of treatment endeavor to favor recovery by immobilizing the spine and removing the overlying weight, combined with the use of tonics. Active treatment is quite secondary to these measures. Open operations are rarely indicated in disease of the spine compared with localized tuberculosis of bones and joints elsewhere. This is largely due to the inaccessibility of the foci in the bodies of the vertebræ.

The seat of disease may be reached by laminectomy and retraction of the cord to one side, as already described. The results of this method of treatment are unfavorable. One case of recovery and 6 deaths have been reported up to the present time.

Another method of attacking the seat of disease, especially in lumbar and dorsal cases, is the paravertebral operation recommended by Schöffer, Vincent, Treves, and others.

Vincent makes a longitudinal incision about 8 to 10 cm. in length at the side of the long muscles of the back. This is carried down to the transverse processes, one or two of which are resected. In the lumbar region, according to Landerer, the free ends of these should be left behind because they are the points of insertion of the muscles of the abdominal parietes. In the dorsal region the posterior extremity of the corresponding ribs must be removed. A similar incision is made on the other side. Any prevertebral abscess may be drained from either side or through the vertebra itself, in which latter case the diseased body of the vertebra must be opened, a task that is easy when the latter has become softened. If one or more bodies are completely destroyed, the drainage will be premedullary. Tuberculous granulations and sequestra may be removed through the above described incisions, although one usually works in the dark and the results are not especially satisfactory. The bodies of the lower lumbar vertebræ can be reached by making an incision parallel to the crest of the ilium similar to the incision used for tying the common iliac artery or abdominal aorta. The soft parts are divided down to the peritoneum, which is separated from the iliac fossa and retracted.

The upper vertebræ might possibly be reached through the mouth. The available space is small, and simple incision alone is all that can be done without any systematic attack upon the tuberculous tissue. Furthermore, it is impossible to perform the operation aseptically in this region, which may be done if the bodies of the vertebræ are approached from the side of the neck. The above mentioned method of Chiene, described in connection with acute osteomyelitis, may be made use of. This author makes an incision along the posterior margin of the sternomastoid behind the large vessels and approaches the anterior surface of the spine in this way. In Burkhardt's method an incision is made along the median border of the sternomastoid and the prevertebral region is attacked between the larynx or thyroid gland and the carotid artery.

The arches are much more accessible than the bodies of the vertebræ, and when affected by tuberculosis, the chances of radical removal of the diseased portion are considerably greater. However, posterior disease is relatively uncommon. Considering the unsatisfactory results following operative removal of tuberculous foci of the spine, it is not surprising that the number of surgeons that advocate these methods is extremely small.

Tuberculosis itself is rarely the primary cause for abandoning conservative treatment. The complications are far more liable to demand radical interference, especially the abscesses. The treatment of cold abscesses has of late been considerably improved. Formerly they were considered a noli me tangere, while at the present time the majority of cases are cured. The more favorable results appeared with the introduction of iodoform treatment by v. Mikulicz.

The author has already stated that abscesses were formerly considered so dangerous because infection of the large cavities after opening the abscess could not be prevented for any length of time, and the patients as a rule died of this infection. It was considered a grave mistake to open an abscess, and every effort was made to keep the overlying skin intact as long as possible. Antiseptic and aseptic treatment did not change these conditions materially, for it is not possible to prevent infection of a profusely discharging wound for any length of time.

At the present time simple incising of cold abscesses has been practically abandoned and routine opening of these is to be condemned. Those cases are exceptions in which incision cannot be avoided, such as is the case with retropharyngeal abscesses that overhang the opening to the larynx and therefore directly endanger life. An incision will rapidly remove the obstruction to breathing, although great caution must be taken to prevent aspiration of pus. In urgent cases when the patient's condition is low it is best to leave the abscess for the time being and perform preliminary tracheotomy. These abscesses are best opened through the mouth, although this method has the disadvantage, aside from the danger of aspiration, that it is absolutely impossible to treat the wound aseptically. If possible, one of the methods should be chosen that attack the focus through the side of the neck, best of which is that advocated by Chiene. Opening of abscesses should be replaced by methods that remove the pus and allow the use of iodoform glycerin. With cold abscesses originating in the vertebræ the latter method can be made use of in the vast majority of cases.

In the clinic at Breslau this is done in the following manner: A medium-sized trocar, to which a syringe containing about 20 to 30 c.c. is attached, should be used. Any punctured wound made with a trocar always has crushed edges, so that it is best to make an incision through the skin about 2 to 3 mm. with a knife and then use the hollow needle. If the trocar is small, this preliminary incision is unnecessary. When the needle becomes plugged with caseous material the lumen may be freed by means of a probe. If the pus is too thick or contains too much solid material, a larger trocar should be introduced. It will always be possible to do this slight operation with the aid of Schleich's anæsthesia, which renders the procedure almost painless.

After all of the pus has been removed or squeezed out by pressure a certain amount of a 10 per cent. solution of iodoform glycerin is injected, according to the size of the abscess and the age of the patient. The trocar is now removed. The author is not in the habit of sewing the wound if made with the hollow needle itself. If, however, a small incision had been made previously, it is customary to close this with a metal or silk stitch. The wound is covered with a small piece of iodoform gauze held in place by a piece of adhesive plaster, and a pressure-bandage, consisting of several layers of adhesive plaster, is applied over this, which not only serves the purpose of diminishing the size of the abscess cavity as much as possible, but also increases the pressure within the cavity. The amount of iodoform solution injected depends on the age of the patient. Generally speaking, the abscess-walls absorb slowly and but slightly, so that large quantities may be injected without producing signs of poisoning. In adults the author has used 100 c.c., and in young children 15 to 20 c.c. The danger of poisoning is due chiefly to the glycerin. When the poisoning is slight, there may be hæmoglobinuria lasting from two to four hours. Later, within twenty-four hours after injection, there follows a rise in temperature and the pulse may reach 115. The amount of albumin in the urine will correspond to the hæmoglobin present, and disappears as soon as this is no longer evident. All of the symptoms disappear during the course of the succeeding few days. When the poisoning is severe, the urine is dark reddish brown with considerable sediment, consisting of kidney elements, casts, and reddish-brown detritus free or adherent to casts. There is also an amorphous precipitate of calcium salts. Red blood-corpuscles, if present at all, are found only in small numbers.

There is much less danger of iodoform-poisoning. Wieland and Dreesmann have reported cases, one of which died. Wieland's case had a temperature of 39.6° C. with a pulse of 180, was pale, had muscular twitching, and the urine showed a marked iodine reaction and some albumin. In the clinic at Breslau a death, probably due to iodoform-poisoning, occurred after an injection of 100 c.c. of iodoform glycerin. The chief symptoms were sopor, increased pulse-rate, stomatitis, and an eruption that covered the entire body. In this case the symptoms were those of iodism. Iodine in the urine and saliva is detected within from three to five hours after the injection, and is present for weeks. The danger of poisoning demands that the patient be kept under careful observation, and that the urine be examined daily for some time after an injection. Slight symptoms of poisoning usually pass off rapidly. If, however, they are very acute and severe, one should prevent further absorption by removing the iodoform glycerin from the abscess cavity by means of a trocar and then washing out repeatedly with sterile salt solution.

By diluting the glycerin it has been attempted to diminish the danger of poisoning. Krause recommends using a solution consisting of 20 parts of glycerin, 80 parts of water, and 5 parts of gum arabic. Verneuil advocates a solution of iodoform in ether, a method still used in France, although the preparation has certain disadvantages and dangers. Evaporation of the ether places the wall of the abscess under such tension that it is liable to become gangrenous or compress important neighboring organs. The injection is also attended with considerable pain, and occasionally symptoms of poisoning are observed due to the ether, such as complete anæsthesia lasting for several hours or vomiting persisting for days.

Various oils have been made use of by v. Bruns and Pöhni as a carrying medium. There is no doubt that glycerin itself has a certain specific action, and the dangers attached to its use are slight if the dose is properly regulated.

Of late an effort has been made to replace the iodoform by formalin. Hahn recommends a 1 to 5 per cent. solution in glycerin. The abscess is aspirated and washed out with boric acid solution and the cavity filled with formalin glycerin. The quantity injected corresponds to about one-third the amount of pus. Experience in the clinic at Breslau is not in favor of this method of treatment.

Ménard has recommended the use of camphor naphthol. After emptying the abscess cavity and washing with boric acid solution, 20 to 40 c.c., at most 60 c.c., of the fluid are injected under moderate pressure. The greater part of this should be washed out again. The few cubic centimetres left are effective. When there is difficulty in emptying the abscess itself, it is probable that it will be difficult to remove the camphor naphthol, and in these cases one should be extremely careful about using this remedy.

When aspirating an abscess, all the usual antiseptic precautions should be observed, for if the bandage is removed too soon, or if the seat of aspiration is unfavorable, infection is likely to result.

It is evident that the injected material must be sterile. In the clinic at Breslau the iodoform glycerin is not sterilized, yet no unfavorable after-effects have ever been noted. Other media, especially olive oil, should be sterilized, but the mixture cannot be boiled for any length of time because the heat destroys the iodoform. It is best to sterilize the oil separately, and after this has cooled add the iodoform. The latter may be rendered sterile by preserving for some time in a solution of corrosive sublimate. If possible, any mixture should be made fresh before using.

Pus containing bacilli may follow along the needle-track and infect the tissues in this way, although an accident of this sort is rare. The author believes that this event may be avoided by using an instrument that has been kept in a 4 per cent. solution of carbolic acid and is used while still wet. According to Baumgarten, the disinfecting material introduced with the needle is sufficient to prevent infection of the track.

Sometimes, however, fluid leaks through the wound and prevents healing. When this takes place, there is always a likelihood of retrograde infection, because pus always contains bacilli. At first the result is a tuberculous sinus. The same condition results when an abscess is aspirated where the skin is altered and thin—that is, where the abscess is pointing.

It is best to aspirate through skin that is as healthy as possible, for then the track is more liable to close and heal up. It is also an advantage to have the track as long as possible, and for this reason the needle should not be introduced at right angles to the skin, but diagonally through the soft tissue. The oblique course of the wound favors closure by the pressure of the abscess, just as the ureter is closed by the pressure of urine contained in the bladder. If one is careful to observe these precautions, it is not uncommon to see portions of the skin that had almost ruptured become healthy again.

Care must be taken not to harm the large vessels, especially in the vicinity of Poupart's ligament, where they may be considerably displaced. The artery can frequently be palpated, and is then easily avoided. When it is not possible to find the vessel, one should aspirate as far as possible from where it is supposed that the vessels lie. Even with the utmost care it may happen that branches of larger vessels are torn, giving rise to annoying hemorrhage. In cases of this sort the only remedy is to open up freely and tie the bleeding points, but it is not alway necessary to open the abscess itself. The incision may be closed after injecting the iodoform.

When the abscess is situated above Poupart's ligament, there is always danger of opening the peritoneal cavity, especially if the abscess is not in contact with the anterior abdominal wall, when the pus will flow from the abscess into the abdominal cavity. This accident may be avoided by waiting until the abscess is surely in contact with the abdominal wall and then introducing the trocar as low down as possible. Abscesses of this sort may have to be watched for a considerable time before they can be attacked, but when this method of treatment is counterindicated one should make an open incision and empty the cavity. The wound should be accurately closed and a small drainage-tube left that reaches into the cavity. A sufficient quantity of iodoform glycerin is now injected through this tube, which is subsequently removed and the wound closed. This method should be employed when the pus is so thick that it cannot be removed by aspiration.

Billroth recommends opening the abscess and curetting the tuberculous focus. After the hemorrhage has been arrested, the wound should be closed and the cavity injected with iodoform glycerin. This method is not to be recommended when the abscess is connected with the vertebræ, because, as pointed out by Billroth, it would not be possible to follow the pus cavity to the primary seat of the disease, even though the incision be extensive.

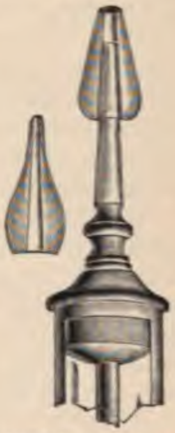
In spite of the iodoform treatment sinuses will develop in a certain number of the cases. Certain sinuses are the result of spontaneous rupture, while others remain after incision. When there has been considerable secondary infection, it will be almost impossible to check the suppuration, and the patients succumb sooner or later. Aside from the fact that the secondary organisms of suppuration are not affected by iodoform, there is the disadvantage that it is extremely difficult to use the preparation, because the injected fluid has a tendency to run out immediately, and prolonged contact between tuberculous tissue and iodoform is the foundation of this method of treatment.

As long as the cavity has not been infected to any great degree an attempt may be made to excise the sinus with a portion of the surrounding skin, free the adjoining tissue, and if possible close the wound. The iodoform glycerin should be injected into the cavity through a drainage-tube which is removed at the close of the operation.

In certain cases favorable results follow a simpler method that is based upon the fact that injected fluids, if under sufficient pressure, are absorbed rapidly—*i. e.*, in the course of five or ten minutes—by the abscess-wall, which then retains some of the medicinal agent.

An especially adapted nozzle must be attached to the point of the syringe. This tip should completely fill the sinus so that no fluid can leak out. (Fig. 292.) The author is in the habit of using an olive-shaped glass tip that may be attached to the nozzle of a syringe containing 20 to 30 c.c., such as is used by Jannet for urethral work. These tips should be preserved in a 4 per cent. solution of carbolic acid. Large drainage-tubes are less reliable. When there are several sinuses, all except one must be closed with gauze pads, and if it is desirable to refill the syringe, or if a sufficient quantity has been injected, the syringe is removed and the sinus closed immediately with a gauze pad until the syringe has been filled again, or until sufficient amount of the drug has been absorbed by the abscess-wall. When the pressure is removed, only a few cubic centimetres of glycerin will flow out. The greater part will remain in the cavity. The immediate result of injection into closed cavities or into those with sinuses is a more or less marked reaction characterized by local tenderness, rise of temperature, increased pulse-rate, lassitude, headache, and occasionally nausea. If a general anæsthetic has been used, a certain proportion of these symptoms is accredited to this circumstance. There is some local reaction during the first few days in the abscess cavity itself, for there is evidently a certain amount of exudation which increases the size of the abscess.

FIG. 292.



Olive-tipped syringe.

During this period of reaction the patients should go to bed. Whether they should be allowed to get up after the period of reaction or not, depends upon whether the condition of the vertebral column renders it necessary or advisable for the patient to be about. After two or three days the signs of local reaction begin to disappear, the tension in the abscess diminishes, and in favorable cases continues to diminish in size during the following few weeks until nothing but scar-tissue is left, which frequently cannot be felt.

In other cases the abscess persists, and aspiration must be repeated after four to six weeks. There is no sense in doing this sooner, because it has been shown that iodoform remains in the abscess cavity for several weeks, and the iodine in the urine indicates whether all of the iodoform in the abscess cavity has been absorbed or not. As long as any remains it will be absorbed and excreted.

Occasionally an abscess disappears partly or completely, and then gradually increases in size. These cases should be aspirated again. There will be found, instead of the typical tuberculous pus, a syrupy, clear, serous fluid. This is rarely found when an abscess is aspirated for the first time. Generally speaking, this is a favorable sign, because the contents of an abscess oftentimes become of a serous consistence previous to disappearance.

When sinuses are present, the injections must be repeated much more frequently ; and if the reaction is slight or absent, they may be repeated two or three times a week or even daily. With these patients the same drug should not be continuously employed. The author has been in the habit of using carbolic glycerin, formalin glycerin, and balsam of Peru, and alternates at regular intervals with iodoform glycerin. With this form of treatment the secretion frequently diminishes, the capacity of the cavity becomes less, the depth of the sinus is less, and finally the wound heals. Occasionally the wound may reopen after a time. In these cases it may be advisable to expose the primary focus freely and remove as much of the tuberculous vertebræ and surrounding tissue as possible. The author has already mentioned that operations of this sort are not always successful. Even when the tuberculous granulations and sequestra can be removed, the stiff walls surrounding the abscess cavity may prevent complete recovery.

Generally the prognosis of cold abscesses when treated with iodoform glycerin injections is by no means unfavorable. v. Bruns observed a large number of cases for from three to four years and reported 80 per cent. of recoveries. The clinic in Breslau reports 73 per cent. of recoveries. These figures do not apply to abscesses of the vertebræ alone, although there would probably be but little variation even if they did.

There is no doubt that injections of iodoform not only affect cold abscesses favorably, but that they also may in many cases have a curative influence on the primary focus in the vertebral column. The pus that burrows to the surface furnishes a canal through which it is possible to reach the primary focus in the spine. The granulations that spring up under the influence of iodoform favor absorption of tuberculous tissue, and cause caseous foci to be surrounded by a firm fibrous capsule. Foci that contain bacilli may in this way be rendered harmless for a considerable time, although after protracted periods they may be the starting-point of a recurrence following trauma or lowering of the power of resistance due to some acute infectious disease or other cause.

A slight amount of space must be devoted to the treatment of paralysis as far as it complicates caries, although not infrequently the treatment of this condition corresponds to that of the primary disease. It should be remembered that paralysis is generally due to involvement of the dura by the tuberculous process, and it may safely be assumed that after recovery from a peripachymeningitis or pachymeningitis, and after absorption of the products of inflammation contained in the vertebral canal, such as tuberculous granulations and pus, the functional disturbances will disappear if there had been no severe organic damage to the cord.

Treatment by extension and horizontal rest in a plaster-of-Paris cast will frequently be followed by improvement of the paralysis even when this has existed for a considerable time. About 50 per cent. of the cases treated by non-operative orthopædic measures recover.

Calot's method, although not to be recommended generally, has a favorable influence in many cases. Six of 8 recovered under this treatment. The fact that 50 per cent. of the cases treated by non-operative measures are unsuccessful has led surgeons to attack the paralysis by an open operation.

Israel and Macewen were first to perform laminectomy for this purpose. Kraske objected to this measure on the ground that the condition was not removed permanently, especially as paralysis due to bony displacement is quite rare. When this condition is present, however, there is a possibility of improving the symptoms by removing the offending portions of bone.

Not infrequently it is possible to relieve the cord by removing the peripachymeningitic pus and masses of granulation-tissue that are frequently the cause of paralysis, but there is little likelihood that any benefit will be permanent as long as the primary focus in the spine itself cannot be removed. In the majority of cases the pus and granulation-tissue will re-form and the symptoms of pressure reappear.

In 3 of the 4 cases operated upon by Kraske the result of laminectomy was at first brilliant for the existing paraplegia diminished. In all the three, however, the symptoms reappeared, and in the fourth case the result was negative from the first. Other authors report similar results. Trendelenburg emptied an epidural abscess the size of a cherry. This was followed by improvement, but later the paralysis reappeared. This in turn disappeared as soon as an abscess that developed at the side of the scar was aspirated and filled with iodoform oil. It is not improbable that in this case the iodoform had a curative effect, whereas the laminectomy, as in Kraske's case, was but palliative.

All of Trendelenburg's 8 cases seem to give a certain amount of information relative to the operative treatment of paralysis in caries of the spine. In all of these the disease had existed at least two years, and the symptoms indicating acute tuberculosis had completely disappeared. In 5 of the cases no signs of tuberculosis could be found on operation; only a diminution in the lumen of the vertebral canal. Three of the 5 recovered, 1 improved, and 1 remained unimproved.

The diminution in the lumen of the vertebral canal producing the paralysis found in 5 of the 8 cases would seem to indicate that the paralysis remaining after the local focus has healed is largely due to displacement. It may also be deducted that paralysis persisting for a protracted time is amenable to operative interference, and the author therefore agrees with Trendelenburg that in these cases laminectomy is indicated.

It is not always possible to say that the primary disease has healed, and there will always be a number of cases in which it will be detected at the time of operation, which therefore were not well adapted for operative interference. In cases showing a tendency to recover it is possible that laminectomy will not interfere with the final result; and considering the hopeless prognosis, it is occasionally better to operate unnecessarily than leave the patients to their fate as long as there is the chance that they might be improved or even cured.

It is not justifiable to claim that some of the cases might recover if they had been unoperated, This must be acknowledged, but it is by no means a matter of indifference whether the paralysis persists for some time or whether it is removed before irreparable changes in other organs, especially the kidneys, have taken place. The prognosis of paralysis is always worse the longer pressure has persisted, for the danger of degeneration in the cord is greater the longer and more intense the application of pressure. In certain of Trendelenburg's cases recovery took place even after the paralysis had persisted for many years, but the fact that the paralysis was not complete proves that the compression was not very extensive. Paralysis due to displacement will probably never recover spontaneously, and can be removed only after correcting the faulty position. The author has already mentioned that Calot's treatment frequently results in disappearance of paralysis.

The treatment of paralysis in caries is as follows: In acute cases it is that of the primary disease, such as extension and horizontal position in plaster-of-Paris casts. When dealing with a process that is resolving or with one that has healed, the above measure may first be tried. Should conservative treatment fail, then more radical measures may be considered, such as .Calot's treatment and laminectomy. Generally, one will be more inclined to try the former operation first, although somewhat modified, considering the disastrous results of too forcible replacement. When this measure has proved useless, resort may be had to an open incision. In the clinic at Breslau an open operation was avoided in two cases by making use of Calot's method.

A certain number of the patients can be treated only symptomatically. These are the hopeless cases in which existing complications render hopeless the preservation of life. Severe kidney-changes and pronounced tuberculosis in other organs, especially in the lungs, are the main conditions to be dreaded in this connection.

Decubitus may render appropriate treatment very difficult, especially if the ulcers are in the immediate vicinity of the field of operation. In these cases open incisions may be absolutely counterindicated because even with absolute asepsis the prognosis is only fair. If the precautions above described (page 644) are observed and the ulcers are at some distance from the intended incision, one may be able to operate with a certain amount of security; and on the other hand, it is reasonable to hope that the pressure-ulcers will heal as the paralysis improves.

With disease of the arches and paralysis one would be much more liable to decide upon laminectomy than in cases in which the bodies of the vertebræ are involved. The objection that removal of the arches deprives the vertebral column of the chief remaining support no longer applies: besides the likelihood of removing all of the diseased tissue is much greater. One should not be too sanguine, because the diagnosis of isolated disease of the arches cannot be made with precision. Experience has shown that the tuberculous process may extend and the paralysis may persist or reappear even when it seems probable that all the pathological tissue has been removed. The beneficial effects of laminectomy sometimes become evident within a very short time, even within a few hours after operation. As a rule, however, the desired result does not appear for a considerable time, and in Trendelenburg's cases the condition was worse immediately after operation. The spastic paralysis became flaccid, the sphincters previously normal became paralyzed, and instead of normal sensation there was extensive hyperæsthesia. Weeks after, the condition was that corresponding to the period immediately before operation, and six months or a year passed before complete recovery took place.

SYPHILIS OF THE SPINE.

Syphilis of the spine is rare. Congenital syphilis is unimportant from a surgical standpoint. The condition is the same as that found in other bones and presents the typical picture of osteochondritis and periostitis. Acquired syphilitic processes in this region belong almost always to the tertiary stage. Usually years elapse before spinal lesions become manifest. In rare cases a primary sore of the pharynx may involve one of the vertebral bodies, but generally pharyngeal ulcerations are of tertiary origin, increase in depth, and involve the upper vertebræ, and occasionally separate an entire vertebral body. (Teissier.) It may happen that after the arch of the atlas and the odontoid process of the axis have been destroyed that the dura is exposed in the mouth. (Autenrieth.)

Syphilitic processes in the spine usually originate in the bone or periosteum. Gummatous caries is liable to affect the upper vertebræ, although the lower ones are not immune.

The clinical picture may resemble that of tuberculosis very closely. There are local pain, more or less kyphosis, cord symptoms, and symptoms due to involvement of the spinal nerves. There are no abscesses connected with syphilis in this region. In the cervical region a gumma along the anterior surface may be associated with difficulty in swallowing and breathing and sometimes resembles a retropharyngeal abscess very closely. There are pain on pressure and on motion, and sometimes spontaneous pain. The latter is usually very annoying, but varies in intensity from time to time. It is frequently worse at night, but may cease entirely for days and reappear with renewed intensity following change in the weather. When the upper cervical region is involved, there will be rigidity of the neck and a condition resembling very closely that of suboccipital disease. In the periods during which the pain is less a greater amount of motion is possible.

The bone destruction may be so extensive, that angular kyphosis results. As in tuberculosis, the kyphosis will be combined with lateral deformity if the focus is not symmetrical. Occasionally the deformity appears suddenly, for a very slight amount of trauma may be sufficient to fracture the spine at the seat of disease. In syphilitic ostitis and periostitis the sequestra may be large. The entire arch of the atlas has repeatedly been cast off into the mouth, an event that has not even been productive of severe after-effects. (L. Fischer, Wade.) The reason why disastrous after-effects do not follow is due to the fact that the bone destruction in syphilitic processes is compensated for by deposit elsewhere, either in the interior of the bone, which becomes ivory-like, or in the region of the periosteum. The exostoses that develop may frequently be palpated. They not uncommonly encroach upon the intervertebral foramina or upon the central canal. When this takes place, they may press upon the nerves or upon the cord, and grave disturbances result. In the regions supplied by the nerves there will be paræsthesia, neuralgia, etc., the latter symptom being produced in the same manner as described in connection with intravertebral extradural tumors.

The cord may suffer, due to displacement of the involved vertebræ, or it may be involved by periosteal intravertebral gummata. It is notable that the comparatively few cases of syphilis of the spine that have been reported were usually associated with severe cord symptoms.

It will be seen therefore that the diagnosis of syphilis of the spine is not easy. It is especially difficult to exclude tuberculosis. There may be no clinical evidence of either disease elsewhere, and the presence of syphilitic lesions in other organs or the negative history is not positive proof in the etiology of the spine lesion. Nevertheless, when one is sure of specific infection, and when there is disease of the spine producing the above mentioned symptoms, he is justified in considering syphilis.

The intermittent character of the pain is suspicious. The age of the patient must be taken into consideration, for tuberculous disease is most prevalent in growing individuals, whereas syphilitic disease is generally found in adults, even in those well advanced in years. The presence of extensive abscesses is, of course, in favor of tuberculosis.

In a certain number of cases it will be absolutely impossible to make a differential diagnosis, and in this event one should endeavor to arrive at a correct conclusion by instituting antisyphilitic treatment. Great care should be taken because it is well known that potassium iodide may have a disastrous effect in tuberculosis. This method of making a diagnosis is frequently unsuccessful, because antisyphilitic measures oftentimes exert no influence whatever upon lues of the spine. The paralysis is especially obstinate, which is more likely to be the case when it is produced by displacement of the vertebræ or by destructive processes in the cord. It is manifest that the kyphosis cannot be removed with potassium iodide or with mercury. Generally speaking, antisyphilitic treatment is, however, effective in lues of the spine. Gummata and exostoses disappear, the pain ceases, ulcers heal, and the deformity ceases to increase.

Treatment.—The treatment consists in the administration of potassium iodide (75 grains daily), increasing the dose day by day. When the result of treatment confirms the preliminary diagnosis, mercury may be employed in some form or other.

The necessary orthopædic measures should not be neglected. Sequestra should be removed if possible, and timely use of extension with rest in bed may limit the permanent deformity. Not infrequently rest in bed is positively indicated because it guards against the possibility of disastrous fracture of the vertebræ. The orthopædic treatment differs in no way from that of tuberculosis of the spine.

ACTINOMYCOSIS OF THE SPINE.

This affection is of little surgical interest, although under certain conditions the ray fungi have produced extensive destruction of the bodies of the vertebræ. The disease is always secondary and occurs in connection with disease elsewhere, compared with which the lesion in the spine is apt to be insignificant.

As a rule infection takes place through the œsophagus, the mouth, the lungs, or the intestines. All of the tissues surrounding the œsophagus, such as the pleura, the lungs, the ribs, etc., become infiltrated by the process. It extends rapidly in the posterior mediastinum, either upward or downward, and exposes a considerable portion of the spine.

Quite a number of the vertebræ are apt to be involved, especially in the lower cervical region. The bodies of the vertebræ are usually affected first. These become infected from the surface and present cavities of varying size. The spine appears eroded and worm-eaten, and the destruction may be so extensive that the individual vertebral bodies collapse, giving rise to angular deformity. This is quite apt to occur because the destruction of bone is not associated with any great amount of reproduction, or the destruction is so rapid that the newly formed masses of bone become destroyed immediately. Ponfick, however, reports extensive osteophytes and active osteoplastic reaction.

After a certain time the process reaches the vertebral canal. In some cases the disease reaches this region through the intervertebral foramina and then extends as peripachymeningitis actinomycotica. The dura itself is seldom involved, and marked disturbance referable to disease of the cord is uncommon.

The transverse processes, the arches, and the spinous processes may become involved, and the disease then reaches the surface in the back. Very extensive infiltrated areas will be found in this region, and an absolute diagnosis may be made from the softened contents, provided an examination of pus from other regions has not already decided this question.

Symptoms.—As far as the symptoms are concerned, the author will consider only those referable to involvement of the spine itself. In the cases reported up to the present time they have been of secondary importance because at the time the disease involves the spine extensively the general condition of the individual is as a rule so poor that symptoms due to involvement of other organs attract more attention.

Actinomycotic kyphosis has never been reported, although the region involved may be very sensitive when the weight-bearing function was taxed or when pressure was brought to bear upon the spinous processes. In the cases reported there were no severe symptoms referable to the cord itself, although neuralgia of the spinal nerves was repeatedly observed, especially intercostal neuralgia. A patient in the clinic at Breslau with abdominal actinomycosis suffered from severe bilateral sciatica.

The infiltration appearing at the sides of the spinous processes usually presents all the characteristics of actinomycosis, and is firm, doughy, and not sharply separated from the surrounding tissues. The doughy consistence is due to secondary œdema.

After a while the regions involved undergo coagulation-necrosis and fluctuate. Softening appears in several regions of the infiltrated area at the same time. On incision there will be found but a slight amount of pus, and at times this will be foul because of secondary infection. In these cases other organisms besides the characteristic fungi of actinomycosis will be found.

Diagnosis.—An absolute diagnosis is only possible after finding the typical ray fungi, and is usually made long before the spine has become involved.

Prognosis.—The prognosis of intrathoracic and intra-abdominal actinomycosis has been somewhat improved by the introduction of the potassium iodide treatment. Quite a number of abdominal cases and cases involving the mediastinum have recovered. (Netter.) Secondary infection has an unfavorable influence on the prognosis. It is not possible to determine in the cases that recover how many of these had lesions in the spine, but it is not probable that involvement of this structure alters the prognosis very greatly provided that the damage is not very extensive.

Treatment.—The treatment consists largely in internal medication —*i. e.*, administration of potassium iodide (45 to 75 grains daily). This drug, as pointed out by Prutz, is not to be considered a specific remedy, and is a preliminary measure to operative interference. The infiltrated area breaks down more rapidly after its use and the fluctuating portions become more accessible. The operation itself is much simplified in this way, and consists chiefly of opening and draining the pockets. When it is possible to curette a cavity, this should be done and the wound packed with iodoform gauze, but with abscesses in the spine this is seldom possible.

SPONDYLITIS DEFORMANS.

Under this term are included, as recommended by Anschütz, a number of conditions that produce more or less extensive ankylosis of the spine by affecting the individual intervertebral disks and joints. The author has already mentioned in connection with tuberculous disease of the spine that acute processes sometimes appear in the lateral joints after acute infectious disease. These usually disappear rapidly, and have in all probability the same etiology as the acute infectious process itself. It was also mentioned that the latter conditions were not infrequently followed by tuberculosis.

Besides these acute processes there are chronic inflammations of the joints of the spine. The condition is not always chronic at first, but may appear as an acute or subacute condition that gradually becomes chronic, just as acute rheumatism of other joints may finally become chronic.

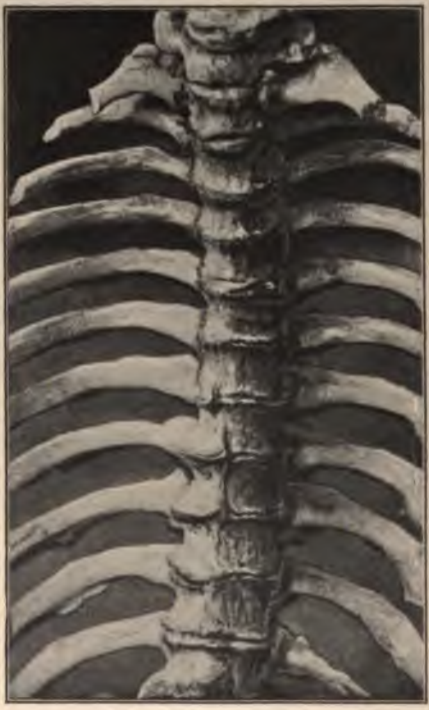
The clinical picture described by Strümpell and P. Marie belongs in this group. (Figs. 293 and 294.) The number of cases reported has increased of late, and it is evident that the condition is not especially rare. Only 4 autopsies have been reported, so that little is known regarding the pathological anatomy.

A large number of the cases described as arthritis deformans belong in all probability to the group of chronic spondylitis deformans. They are frequently associated with similar processes in other joints. Certain other conditions are, however, in all probability secondary to habitual deformity of the spine, and will be considered later.

There must be also considered in this connection a symptom-complex to which Bechterew has applied the name "chronic stiffness of the spine." The patients are as a rule males in the third or fourth decade, or well advanced in years. Women and younger individuals, however, are also affected at times.

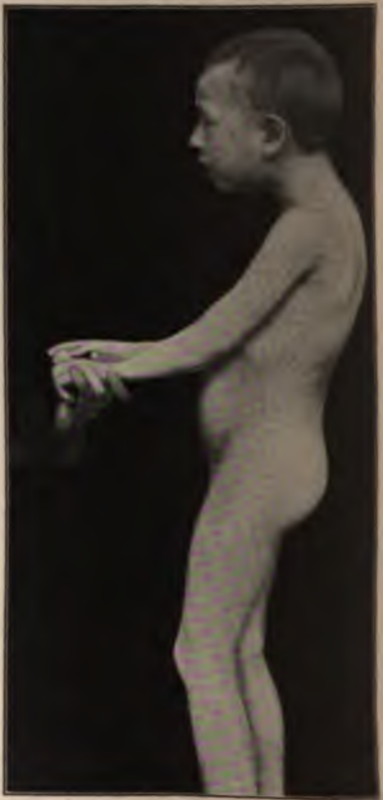
Etiology.—The etiology is clearly not one and the same in all cases, for the decrease is secondary to any affection that produces chronic changes in other joints, but which in the particular case involves the spine. The other joints may not be involved, although as a rule one or more of these is affected, especially the hips, the knees, the shoulders, or the jaws. In the very severe cases almost all the joints of the body may be attacked.

FIG. 293.



Spondylitis deformans. (Goldthwait.)

FIG. 294.



Spondylitis deformans in a child. (Whitman.)

There are usually pain, swelling, and effusion into the joint that may disappear without after-effects. On the other hand, the process may produce ankylosis and in rare cases deformity. In the latter case the pain, which was violent at first, is apt to disappear with increasing rigidity. During the course of the disease one joint may recover while another becomes involved. The whole condition is probably an infection, although there are no accurate data on this subject. Among the cases reported are several in which the condition in the spine developed after an attack of acute articular rheumatism. In other cases it developed after gonorrhœa. Not infrequently "catching cold" is given as the cause, and some slight trauma may be of importance.

Heredity seems to have some influence. In Hoffmann's case the symptoms appeared following a severe acne, and disappeared with improvement of the skin lesion. A rise in temperature is uncommon in the early stages.

Symptoms.—The condition is apt to manifest itself first as a localized pain in the small of the back. The spine gradually becomes rigid. At first there are limitation of motion, and later complete ankylosis of the region involved. The lumbar, lower and middle dorsal vertebræ are more apt to be the seat of disease, and the lesion is more liable to extend upward than downward. In some cases the entire column, including the head, may form a stiff, immovable mass, and the costal joints are affected and fixed, so that costal breathing is impossible. Only in rare cases does the spine become fixed in an extended position. As a rule there is kyphosis, especially in the upper region, and in some cases there may be kyphosis in the lumbar region. Occasionally there is a certain amount of scoliosis. The pain in the back that is present at first usually disappears as the disease progresses. This pain, however, may be absent, while other cases are associated with constant violent pain, especially those developing after an attack of gonorrhœa. Sometimes it is possible to palpate exostoses in the accessible regions of the spine. These may possibly explain the difficulty in swallowing present in certain cases.

Nerve symptoms are usually absent, especially in the severe type; whereas symptoms varying in intensity and importance, such as muscular atrophy, disturbances of sensation, and abnormal secretion of perspiration, may all be present at the same time. The long muscles of the back become atrophic and rigid. Hoffa reports that in his case the muscles were under considerable tension which relaxed under anæsthesia.

The gait and bearing of the patient are influenced corresponding to the extent of the spine involved. When the upper segment remains free, the patients are frequently not aware of the ankylosis lower down. The condition becomes pitiable when other important joints are ankylosed at the same time. Stiff hips with movable knees still allow of more or less awkward walking. When the knees or the ankle-joints are involved at the same time, the body is stiff and rod-like, and even sitting is impossible without especial apparatus.

The disease runs an extremely chronic course, as already mentioned, and the symptoms progress steadily. Only one case of acute fixation of the cervical spine has been reported. (Heiligenthal.) On the other hand, improvement and complete disappearance of all symptoms have been repeatedly observed (Hoffmann), and in one case recovery was followed by recurrence after three years (Gasne).

The autopsies explain the above conditions. In P. Marie's case there were ossification of the ligamenta flava, bony ankylosis of the lateral joints, and bony union of the bodies of the vertebræ. The latter had developed without involvement of the intervertebral disks by the ossifying process extending from one body to the other. The spinous processes were thickened and showed a tendency to become united. Glaser found a similar condition. In one of Milian's cases there was ossification of all the small joints. The fact that the intervertebral disks are not involved may sometimes be determined during life by means of the *x*-rays. (Hoffa.)

Surgeons will be obliged to rely upon further investigation to determine whether or not the intervertebral disks are not involved in all cases in which the lateral joints are ankylosed, and whether this is the chief characteristic of the disease, and whether the other conditions are secondary. The nerve symptoms present in rare cases are probably always due to the overgrowth of bone and pressure upon the trunks.

The chronic rigidity of the vertebral column mentioned by Bechterew cannot be separated from this clinically. This author claims that heredity and trauma are important factors in the etiology of the conditions described by him, and that the disease extends from above downward and is limited to the vertebral column. There are localized tenderness and involvement of the nervous system, which, according to Bechterew, is a primary ascending degeneration with destruction of the roots and paralysis of the long muscles of the back. The disks are said to become atrophied on account of the sinking down of the bodies of the vertebræ. The latter finally touch and become united by bone. The author does not intend by including all of the conditions described under the names chronic rheumatism, arthritis deformans, etc., in the term spondylitis deformans to express the opinion that the clinical picture is uniform. It would be possible to subdivide the condition if the etiology were taken into consideration, and then describe rheumatic and gonorrhœal types, etc., but up to the present it has been impossible to make any differential diagnosis from the symptoms.

Diagnosis.—The diagnosis of spondylitis deformans is not difficult when there is extensive involvement of a considerable portion of the spine, as well as changes in other joints. In cases in which the spine alone is involved, and perhaps only a certain amount of rigidity without fixation, it will be more difficult to arrive at correct conclusions. In tuberculous disease without deformity, abscesses, and cord symptoms, the spine may be rigid, due to muscular contraction. Irritation of the psoas muscles may be followed by flexion on one or both sides. In these cases, however, there are usually considerable pain and local sensitiveness to pressure. Rest in bed is soon followed by relaxation of the muscles. Under certain conditions it may be necessary to make use of a general anæsthetic for the purpose of deciding whether the rigidity is due to muscular spasm or to bony ankylosis. It may be far more difficult to distinguish traumatic spondylitis, for in these cases the symptoms are complicated by exaggeration and simulation. In these cases too it is necessary at times to exclude reflex or voluntary muscular contraction by means of a general anæsthetic.

Once in a while a history of previous joint-rheumatism or gonorrhœa will throw light in an individual case upon the nature of the infection. When the condition in the spine is associated with violent pain, one will be more apt to consider gonorrhœa, especially if the symptoms appear first above and extend downward instead of the usual ascending progression. (P. Marie.)

Prognosis.—The prognosis is favorable as far as life is concerned. It should be remembered, however, that the immobility of the ribs, due to ankylosis at the joints, has an unfavorable effect upon the lungs on account of the limitation of thoracic respiration. Any pathological change in the pulmonary apparatus is, of course, correspondingly more severe. The author has already mentioned that the disease may disappear, that recurrences do occur, and that the condition usually progresses steadily without showing tendency to improve. The difference in the course depends in all probability upon the kind of infection. When bony ankylosis has become established, it becomes permanent.

Treatment.—Treatment is usually unsuccessful. Internal medication, such as salicylic acid, sodium salicylate, antipyrin, etc., is of little value. Salol and potassium iodide are said to have been beneficial in certain cases. Hoffa recommends massage and exercises. Strümpell advises passive motion under anæsthesia, whereas Bäumler recommends immobilization. Tincture of iodine, baths of various sorts and temperatures of varying degrees have also been tried. Occasionally these measures are followed by more or less improvement, and rarely recovery does take place.

TUMORS AND ECHINOCOCCUS CYSTS OF THE SPINE.

Most all the tumors developing in the spine are malignant, and are hopeless as far as radical cure is concerned.

According to Schlesinger's figures, tumors of some sort were found in about one-fifth of 35,000 autopsies in the Pathological Institute in Vienna, and 107 of these tumors—*i. e.*, 1.5 per cent.—were of the spine, the malignant variety being ten times as common as benign growths.

The vast majority of the tumors of the spine are carcinomata that have either extended from neighboring organs or developed there as metastatic growths, and are therefore always secondary. Occasionally a primary carcinoma of the spine is described. This is probably due to the fact that in certain cases it is extremely difficult to find the primary focus, which may be in the mammary gland, the thyroid gland, the œsophagus, the uterus, or in the stomach. Bronchial carcinomata that are extremely uncommon are very apt to have metastases in the vertebral column, although any cancer, whatever its position, may produce metastases in the spine. Direct extension is observed especially in connection with cancer of the stomach and of the œsophagus. The prevertebral lymph-glands may act as conductors. The fact that the breast and the uterus are frequently the primary seat of disease explains why cancer of the spine is especially common in women. On the other hand, men may have cancer of the breast with metastases in the spine.

The cancer is found most often in the dorsal or lumbar region, and the focus is usually in the body of the vertebræ. The process extends toward the periphery, so that finally nothing is left but the cortex, the arches and the spinous processes becoming involved secondarily.

Several vertebræ may be involved at the same time, even all the bodies from the neck to the sacrum. Only in exceptional cases is this multiplicity due to direct transmission from one vertebra to another, and it is usually the result of multiple metastases. The fact that the cortex remains intact for a protracted period explains why the vertebræ do not collapse until late. This event may be delayed until there is considerable new formation of bone (osteoplastic carcinoma, v. Recklinghausen), although in the majority of cases the amount of new bone formed is slight.

When there is deformity, the kyphosis is not apt to be sharp, but forms an obtuse angle or arch with a large radius corresponding to the number of vertebræ involved. It sometimes happens that the entire vertebral column collapses and is shortened. This deformity appears gradually, and Guinon reports a case in which the patient within eight months became about 9 cm. shorter. On the other hand, the spine may become suddenly kinked or collapsed after slight trauma.

It is comparatively uncommon for a cancer to extend beyond the limits of the individual vertebræ, and it is extremely rare to have the tumor masses develop to such an extent that they can be palpated. More frequently the extradural fat is involved, but it is rare to find any disease of the dura itself. The cord may be compressed by extradural masses of cancer, although it is more common, as in caries, to have the symptoms due to congestion œdema of the cord. Sometimes the cord suffers on account of bony displacement.

The spinal nerves are in greater danger than the cord itself, because the intervertebral foramina are encroached upon and they are liable to be compressed. When the tumors masses are prevertebral, then the nerves may be involved after leaving the spine.

Sarcomata are found secondarily in the spine just as carcinomata, either as metastases or on account of extension from the neighborhood. Primary sarcoma of the spine, however, is more common than primary cancer. Any kind of sarcoma, or mixed sarcoma, may be found in this region. The primary growth develops in the bones or in the periosteum, and more frequently in the body of bones than in the arches or their processes, although sarcoma of the bodies may in advanced cases involve the arches or even the spinous processes. Several vertebræ or even extensive sections of the spine may be simultaneously involved. Sarcoma is in a way more malignant than carcinoma, because it is more apt to encroach upon the vertebral canal, and in rare cases penetrates the dura and attacks the cord itself. In the vicinity of the spine tumor masses are found which may extend as far as the superficial skin and undergo degeneration, producing extensive, foul, suppurating ulcers.

Finally there remains to be mentioned the myeloma, which is always multiple and involves several bones of the trunk. This growth is apt to produce softening, and occasionally sclerosis. There is apt to be kyphosis with lateral deformity. The cord is almost always pressed upon either by displaced bony tissue or by masses of tumor encroaching upon the lumen of the canal.

The bony and cartilaginous tumors are grouped together, because they are almost always ossifying enchondroma, especially the cartilaginous exostosis. Schlesinger has reported 2 cases of the former that produced marked stenosis of the vertebral canal. Virchow reports a case of enchondroma which developed to the size of a hazelnut between the spinous processes and the dura mater, and which produced paraplegia because of compression. A similar case, with extensive new growth, was operated unsuccessfully by Bardeleben. The enchondromata of the two latter cases were not ossified.

Cartilaginous exostoses are relatively common in the spine. They are usually multiple, and similar tumors are apt to be found in other bones. Those in the region of the spine become of clinical interest only when they develop toward the vertebral canal and produce nervous symptoms. In a case reported by L. Bruns, and in 3 cases mentioned by Weber, the cauda equina and the cord were pressed upon.

The masses of callus forming after fractures, which produce pressure-symptoms referable to the cord, belong to bony tumors. Lloyd, Brand, and Duplant have reported cases.

A case of benign new growth reported by D. Gerhardt remains to be mentioned. This was an angioma of the spine that had caused complete transverse separation of the cord.

Two processes that during their growth produce symptoms resembling those of tumors should also be mentioned in this connection, aneurism of the aorta and echinococcus cysts. Aneurisms of the aorta may erode the spine to such an extent that the nerve-plexuses and nerve-roots, and even the cord itself, are seriously damaged. They act therefore exactly as do the prevertebral malignant growths. Echinococcus cysts develop rarely in the vertebral column, but when this does take place they are apt to produce spontaneous fractures. In the later stages they may burrow around to the back and rupture in this region.

Symptoms.—The symptoms of malignant disease of the spine may be subdivided into those that are referable to the process in the bone itself and those that may be referred to the nervous system, either to the roots or to the cord itself. The bone symptom is apt to be local pain, which, however, may be absent; in other cases it may be present, although limited to a few vertebræ, even when almost the entire column is involved. This pain may be spontaneous or produced by pressure or motion, such as coughing, etc. In some cases the sensitiveness to pressure is slight or absent, although the spontaneous pain tortures the patient continually. Not infrequently there may be absence of pain over the spinous process, although there is marked sensitiveness to pressure at either side. (Schlesinger.)

The symptoms referable to destruction of bone have already been considered. There may be no bony deformity whatever, and when present there is apt to be a rounded deformity with large radius, very rarely acute angular deformity, or "telescoping" of the spine. The deformity not infrequently appears suddenly, and compression-fractures or, more frequently, complete dislocation with fracture, combined with lateral displacement, are associated conditions.

Besides the deformity produced by destruction of bone there may be that produced by the tumor mass itself. This applies especially to the cases of sarcoma and enchondroma, rarely to carcinoma, and the deformity may be appreciated by examination of the neck, of the back, or of the sacrum by rectum or vagina. Tumors may be felt in several of these regions at the same time, and may be apparent even on inspection, which is, of course, the case when they rupture through the skin or ulcerate. Occasionally the disturbances of circulation indicate their unilateral seat. Oppenheim reports a case of sarcoma in which the veins of the diseased side were much distended.

The symptoms due to compression or infiltration of nerves are the chief signs of malignant disease. A most vicious type of neuralgia is apt to be present. The intervals that at first are of considerable length between the individual attacks become shorter while the attacks themselves lengthen until there is most fearful continual pain. The process itself is usually symmetrical, so that the neuralgia is apt to be bilateral. Even when the new growth involves a considerable portion of the spine the neuralgia may be confined to a comparatively small area.

The pressure is liable to affect the nerves after the roots have joined, although it is questionable whether the muscular spasm is due to irritation of the motor portion or whether it is reflex. The author has already mentioned that paralysis secondary to compression of the nerves themselves is comparatively rare, but paralysis may be caused in this way as well as trophic disturbances.

Root symptoms are present in about 60 per cent. of the cases, and in the course of time cord symptoms develop followed by a fatal termination usually within four weeks. These cord symptoms appear as the result of pressure and are but rarely those of unilateral lesions. When the spine collapses suddenly, the cord becomes contused and the symptoms differ in no way from those produced by ordinary trauma.

As far as benign tumors are concerned, there are no symptoms due to destruction of bone and the signs are those referable to the nervous system alone. The clinical picture corresponds exactly to that of extradural growths.

Diagnosis.—It is usually difficult to make a diagnosis of tumor of the spine, and considerable time will elapse before one is reasonably certain of the condition. With benign tumors, such as the exostoses, the probable cause of the nerve symptoms is fairly certain provided the clinical picture corresponds to that of an extradural tumor, and the physical examination shows benign bony tumors in other regions of the body.

Myelomata form a class by themselves. This general softening of the bone can be confounded only with osteomalacia. Myelomata, however, are found not only in the region of the spine, but also in other bones of the trunk, and the result of phosphorus treatment, usually so effective in osteomalacia, is negative. Furthermore, with severe cord symptoms the extremities are not involved.

Malignant tumors that first produce bone symptoms, then root symptoms, and finally cord symptoms, correspond almost completely to certain other spinal processes, especially with caries as already mentioned. These three groups of symptoms are not always well marked, and the sequence of their appearance may be very irregular; for instance, there may be complete absence or very vague motor symptoms, although neuralgic pain has been present for a considerable length of time, so that it may be supposed that one has to deal with simple neuralgia or neuritis. In these cases the intolerable pain that is only temporarily relieved by treatment will lead one to suspect a tumor. This is still more likely to be the case when the neuralgia is bilateral, and according to Charcot, double sciatica is very liable to be produced by a new growth.

When bone symptoms are present, it may be difficult to distinguish a tumor from caries of the spine, a condition much more common. The age of the patient is of value in this connection, for caries is more liable to occur in youthful individuals, whereas carcinoma and sarcoma are more prevalent in those more advanced in years. Sarcoma may be found in children, and caries is not uncommon in older individuals.

The sudden appearance of deformity is more common with tumors than in tuberculosis except in the cervical region, where the spine may collapse in this manner. "Entassement" or "telescoping" is a variety of deformity that probably occurs only with tumors, whereas an arch-shaped kyphosis may perfectly well be the result of Pott's disease.

The presence of tumors at the side of the spine is of great importance, although it should be remembered that tuberculous infiltration, especially in suboccipital disease, may closely resemble a new growth. The presence of a well-marked abscess will decide the diagnosis in favor of caries.

A primary growth elsewhere is of the greatest diagnostic importance in carcinoma, and frequently in sarcoma, although this is not necessarily positive evidence, for caries of the spine may develop after carcinoma has existed elsewhere for some time. The primary tumor itself may not be found during life, because the symptoms produced by it are comparatively insignificant compared with those produced by the lesion in the spine. If, however, a tumor can be found, or if the history shows that a malignant growth has been removed by operation previously, the presence of symptoms referable to the vertebræ, to the roots, or to the cord, should give suspicion of a new growth in the spine. It should be remembered that the interval between the appearance of primary disease and secondary development may be of years' duration. L. Bruns reports a case of cancer of the spine that appeared eight years after excision of a carcinoma of the breast.

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The root symptoms are much more important from a diagnostic standpoint. It has already been mentioned that root symptoms may occur in caries, but that they are apt to disappear rapidly in this disease, at least in the majority of the cases. (Gowers.) Root symptoms in tumor cases, on the other hand, are apt to persist for some time. There may be pronounced trophic muscular disturbances in caries, although as a rule these do not have time to develop as is the case with tumors. (Bruns.)

Inasmuch as the deformity is quite apt to appear suddenly, the accompanying cord symptoms due to tumors are much more likely to resemble those due to some contusion or to a complete transverse lesion, as in caries. On the other hand, unilateral lesions produced by the pressure of a tumor are more frequently found than in tuberculous disease.

The subsequent course of the disease is of diagnostic value, because the disappearance of infiltration and recovery absolutely exclude malignant new growths. In certain cases extension will distinguish the two conditions, for in the majority of cases of Pott's disease the pain will become less or disappear entirely under this treatment, whereas if the symptoms are due to a tumor the pain is very apt to become worse. The differential diagnosis between tumors of the spine and tuberculosis is just as difficult as an attempt to distinguish syphilitic spondylitis from the tuberculous variety, or from tumors of the spine. The effect of potassium iodide may sometimes give the desired information.

The differential diagnosis between tumors of the spine and intravertebral tumors may be very difficult indeed. The chief distinguishing datum is the variation in the sequence of symptoms. With tumors of the spine the bone symptoms appear first, the root symptoms next, and finally the cord symptoms; while with intravertebral tumors the root symptoms appear first, then the cord symptoms, whereas the bone symptoms appear quite late.

It has already been seen that there are many variations from the usual; and it must furthermore be remembered that secondary tumors are far less liable to develop in the vertebral canal than in the substance of vertebræ. When it can be determined that the condition is of metastatic origin, it will be more probable that the vertebra is affected. (L. Bruns.) In certain cases it is possible to distinguish the variety of tumor with more or less certainty; for instance, when there is a primary carcinoma or sarcoma elsewhere, or with exostoses in other regions of the body. If no primary growth can be found, one would be more apt to consider sarcoma, as is also the case when the growth extends beyond the spine and involves the surrounding regions. An echinococcus cyst can be recognized only by examining the contents after aspiration, after incision, or after spontaneous rupture of the sac.

Prognosis.—The prognosis of malignant tumors of the spine is unfavorable. According to Schlesinger, the average duration of life is about nine and one-half months with carcinoma and eleven months with sarcoma. Three and one-half years is the longest period reported in carcinoma and two and one-half years in sarcoma. The shortest period is one week in carcinoma, and two months in sarcoma after onset of symptoms.

With exostoses the symptoms may at times remain stationary because the growth ceases to increase in size after having reached certain dimensions. If nerve symptoms have developed, they will persist.

Echinococcus cysts may rupture spontaneously and recovery may follow. (Hasse.)

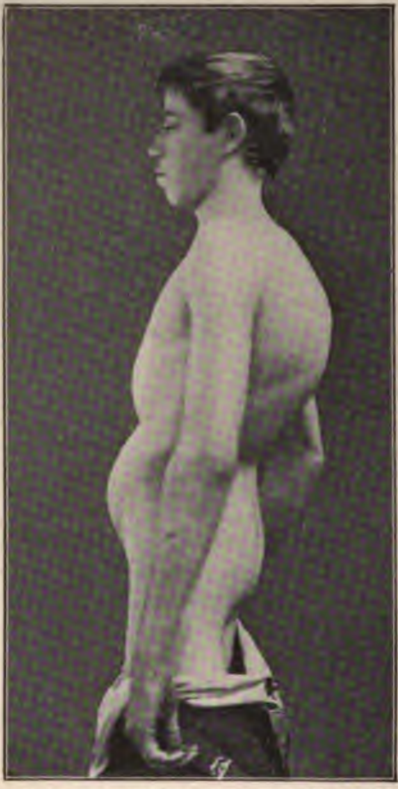
Treatment.—The treatment of malignant tumors is chiefly symptomatic, and pain is the main symptom to be combated. The author has already considered the measures to be taken when there is paralysis. Immobilization may be attained by use of the plaster-of-Paris bed, and in this way the danger of sudden collapse of the spine can be avoided. Extension is not well borne. When there is doubt as regards the diagnosis, potassium iodide may be used carefully. Occasionally one may have to resort to an exploratory incision to decide these questions, especially when there is a possibility that the tumors may be benign.

Exostoses and excessive formation of callus are the most favorable subjects for operative interference, although it should be remembered that these conditions may reappear. The results of operative interference in echinococcus cysts are fairly good, although the diagnosis is more difficult than in all the other conditions. In cases of carcinoma, operative interference is useless, not only on account of the usual seat of the growth in the body of the vertebræ, but because as a rule the process involves a considerable portion of the spine. The chances are more favorable perhaps in sarcomata because these sometimes develop in regions of the spine that are more accessible, especially in the arches. Kümmell and Calley report one case each of sarcoma of the spine that improved after curetting. Sonnenburg reports a similar case, although in this case the growth was so extensive that radical interference was counterindicated. There was, however, considerable improvement of the nerve symptoms. These few cases will at times justify the surgeon in deciding upon laminectomy, although the presence of malignant tumors in other organs is an absolute counterindication to radical interference in the region of the spine.

CURVATURES OF THE SPINE.

These conditions are due to static, postural, myopathic, and neuropathic causes, and also to general diseases of the osseous system. The diseases of the spine which have been considered were limited with few exceptions to individual vertebra or groups of vertebræ. The conditions that remain to be considered involve larger sections of the spine or affect the whole body simultaneously. The resulting deformity is not angular but rounded, the curve having a large radius. In a certain number of diseases the cause of these curvatures is found in the spine itself; the abnormally soft texture of all the bones in the body in rhachitis makes itself evident in the spine as some change in shape. Furthermore, displacement of the centre of gravity, either due to intraspinal or extraspinal causes, is followed by abnormal curvatures that attempt to correct the error. With shortening of the right leg the trunk will sink on the affected side if there is not compensatory static curvature with the convexity toward the right side. Curvatures may also be produced by insufficient or totally absent muscular action, a force which ordinarily helps to maintain the normal posture. Any weakness or paralysis of the muscles, or of the nerve-elements supplying them, results in insufficient tension upon these muscles and postural curves, generally the result of faulty volition.

FIG. 295.



Extreme posterior curvature of the spine in adolescence, showing retraction of the abdomen. (Whitman.)

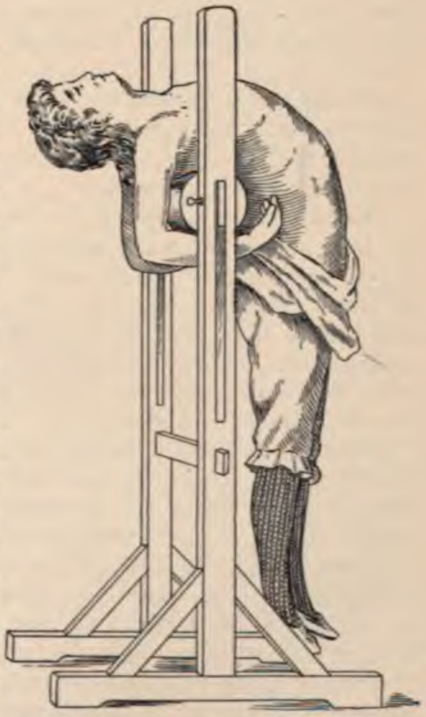
Besides the soft bones found in many cases, certain positions may produce some deformity (occupation curves). In themselves these curvatures are not pathological, of course. They become so as soon as the ligaments, muscles, and bones adapt themselves in such a way that the average position of the spine has been so changed that a normal position cannot be resumed actively, and later not even by passive force. There is first a position due to contraction, and then fixation in the pathological position. The results of this deformity will be considered later. These bony curvatures, in the restricted sense of the word, as well as the static, occupation, myogenous, and postural curvatures, although having different etiology, correspond so closely in their symptoms that they can be considered together. It should be remembered that the scoliotic curvatures of the spine belong really to orthopædic surgery, although some knowledge of the subject is of great importance to the general surgeon.

Sagittal Anomalies of Posture.

Certain transitional stages from the normal to the pathological, such as the flat and hollow back, have been considered elsewhere. These types resemble the normal condition closely because the usual curves of the spine are present, to be sure, although they are in the one case too exaggerated and in the other insufficiently developed. They can be considered pathological only when they are so pronounced that the exaggerated curve in one section of the spine cannot be compensated for by compensating curvatures in the neighboring regions, for instance, when abnormal kyphosis of the back is not compensated for by the lordosis in the lumbar region or in the neck, or even involves these two regions in the kyphosis. In cases of this sort the compensation which maintains an erect posture is chiefly in the hip-joints.

Kyphosis.—Most of the etiological factors above mentioned may result in a kyphosis, which therefore may be based upon rhachitic, postural, occupation, and paralytic factors. Postural kyphosis, the "round back," develops in individuals between seven and sixteen years of age, and is equally as common in boys as in girls. Heredity is of a certain amount of importance in the etiology. The chief cause is, however, a certain lack of energy. The children do not become accustomed to keeping the muscles of the back under sufficient tension to maintain an erect position. They allow themselves to droop forward as far as the bones and the ligaments will allow. Certain occupations have a tendency to increase the rounded position, such as writing, piano-playing, fine needle-work, reading fine print, especially when the light is poor or vision is defective, necessitating close approach of the work to the eyes. Improperly constructed desks in schools not infrequently favor round shoulders. The injurious effect of these influences increases with the length of time to which the individual is subjected to them. Besides the lack of energy, the individuals tire easily. Desks in school are frequently

FIG. 296.



Exercise for the correction of posterior curvatures of the spine. (Lorenz.)

harmful because the backs are shaped in such a way that it is difficult or impossible to rest in the intervals between work.

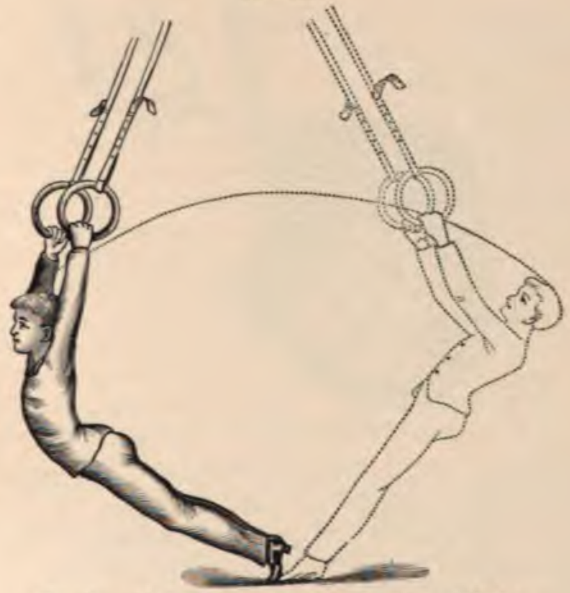
Symptoms.—The symptoms of postural kyphosis are very pronounced. The spine forms an arch with the convexity backward. The cervical lordosis is completely absent or but slightly developed. The head and neck are held forward, the shoulders follow, and the shoulder-blades stand off. The lumbar lordosis may also be absent or but slightly marked; the junction of the lumbar column with the sacrum, on the other hand, forms a sharp kink. These individuals hold themselves erect by lifting the pelvis. This flattens the gluteal region and the stomach seems prominent. This latter position seems more exaggerated because the chest itself is flattened and sunken. The whole attitude of the patient is lax. The feet "toe in" and the knees may be held slightly flexed. The diagnosis of postural kyphosis is easy, especially when the age of the individual is taken into consideration. Round back differs from kyphotic curvatures due to inflammatory conditions, such as tuberculosis and spondylitis deformans, chiefly by the absence of inflammatory symptoms, as pain, for instance, and especially by the fact that the deformity can be corrected even by the patients themselves, provided it has not persisted for too long a time.

Prognosis.—The time that the condition has lasted has considerable influence upon the prognosis, for the longer the symptoms have been present, the more difficult it is to remove the deformity. In the early stages this may be quite easy.

Treatment.—The treatment must first of all be directed against the lack of energy on the part of patients. Not infrequently one can appeal sufficiently to their vanity by referring repeatedly to the unsightly position they maintain to induce them assume a better posture. All factors that tend to favor the condition should be avoided: improperly shaped desks should be replaced, and sitting and working with bent-over shoulders should be avoided; myopia should be corrected. Another element of the treatment consists in strengthening the muscles, not only the long muscles of the back, but also the latissimus and trapezius. Massage and gymnastics, exercises in swimming, flexion and extension of the trunk; all of these are of value. The patient should lie face downward upon a padded table with his ankles strapped down. He should then be instructed to lift his body off the table with his back muscles. (Fig. 309.) Exercise on flying rings, rowing apparatus, calisthenics with wooden rods and dumb-bells, exercises in marching and in carrying weight on the head should be tried. Certain of these exercises will be described later in connection with scoliosis. If there is contraction, this should be removed if possible and the spine mobilized. This may be done in slight cases by suspending the patient in a Beely frame, or by hanging exercises as depicted in Fig. 297. The knees should always be kept extended. In severe cases the exercises should be performed with a Wagner apparatus (Fig. 314) or with a Lorenz roller (Fig. 296). The surgeon should assist the active efforts of the patient by still further depressing the shoulders.

None of these exercises should be carried to the point of exhaustion, and recesses should be allowed so that the children may recover. During these intervals the patients should be placed on an inclined plane. The head should be suspended in a Glisson sling and a transverse board should support the feet. A pillow placed between the shoulder tends to produce lordosis of the spine in general. The shoulders should be strapped to the inclined plane.

FIG. 297.

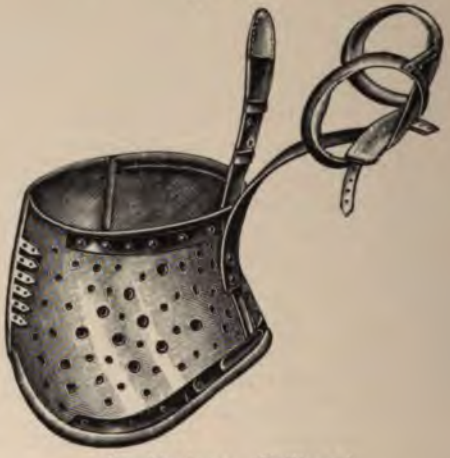


Exercise on flying rings to overcome kyphosis. (Hoffa.)

When massage and gymnastics are not sufficient, some appliance, such as a brace, may be added. Nyrop's apparatus is valuable in this connection. A perpendicular spring standing off from the back is attached to a pelvic band. A transverse piece to which straps are fastened is arranged at the level of the shoulders. These straps pass around the shoulders, and the spring of the vertical rod tends to pull the shoulders backward. Dolega uses a small abdominal jacket, similar to a celluloid jacket, instead of a pelvic band. (Fig. 298.) Hessing's corset may also be combined with a spring behind. The shoulder-braces made on the suspender plan are to be condemned. If they do any good at all by pulling the shoulders back, they also do harm by depressing the shoulders. If one is ordering a shoulder-brace, one should always understand that this tends to weaken still farther the muscles by perpetually releasing them. This disadvantage must be offset by continual massage and gymnastics, and is also the reason why shoulder-braces should be avoided as much as possible. They should never be ordered unless all other means have proved hopeless.

If a postural kyphosis when persisting for a sufficient length of time is able to alter the spine, especially the ligamentous arrangement, then this applies to a much greater degree to the conditions due to occupation and to those forms of curvature that develop owing to actual insufficiency of the extensors of the back. Besides the paralytic curvatures proper, in this connection should be mentioned the senile kyphosis due to the muscular weakness of old age.

Fig. 298.



Shoulder-brace. (Dollinger.)

Flexion of the spine is secondary to a diminution in the diameter of the intervertebral disks along their anterior margin, which again is secondary to a flattening of the synchondrosis most marked in front. If the change is permanent, the disks soften and become atrophied (brown softening, Luschka), and there is an increasing loss of elasticity. The lateral bands contract and the flexed position becomes fixed. Simultaneously with a diminution in the elasticity of the disks there is a diminution in the elasticity of the spine as a whole. Blows in the longitudinal axis or even physiological impulses, such as walking, are transmitted directly to the vertebræ and are not broken by the soft pads in the synchondrosis. Each step that the patient takes is in a way a variety of truma. On account of this continued irritation changes in structure develop in the vertebræ. The external surface becomes deformed by bony outgrowths—osteophytes. These affect chiefly the anterior regions of the synchondrosis, and finally lead to synostosis of extensive sections of the spine. (Rokitansky, Benecke.)

The ankylosis found in almost every case of severe senile kyphosis must be explained in this way, as well as the osteophytes which are to be found almost always in the spines of the aged. The changes found in the cases of occupation kyphosis, especially in the variety due to the carrying of weight, should in all probability be included in this group. Those cases described as arthritis deformans or spondylitis deformans should in all probability be included among the conditions described on page 757. Besides the abnormal softness in the osseous system, weak muscular development is of considerable influence in rhachitic kyphosis. This condition is found chiefly in children during the first year of life or in the beginning of the second year. The lower region of the chest and the upper lumbar region are generally affected, while the deformity becomes especially marked on sitting down.

Diagnosis.—The diagnosis is made because of rhachitis elsewhere, and is usually easy. In some cases, however, the differential diagnosis between tuberculous disease is very difficult. The rhachitic deformity disappears as a rule when the child that has been placed on its stomach is lifted by the feet. In these cases the lordosis will be very marked, whereas in tuberculous disease the deformity will persist. Occasionally, however, the rhachitic kyphosis becomes fixed by muscular spasm, and any attempt to correct the deformity produces pain.

Prognosis.—The prognosis is favorable as long as the kyphosis is not complicated by lateral curves.

Treatment.—The treatment should be directed against the constitutional disease in general, besides attacking the local process. The food should consist of a mixed diet of proteids and carbohydrates, plenty of fresh air, salt baths, and codliver oil. The treatment of the deformity consists in strengthening the muscles of the back by massage and in fastening the children to a plaster-of-Paris cast, as already described. The head in these cases need not be included. This method is to be preferred to placing the patients upon a hair mattress, as frequently prescribed, first because rhachitis is more frequent in the poorer classes, by whom hair mattresses are not procurable, and, second, because the children, if not tied down, will not lie quiet unless under continual observation, which is not possible in the lower classes. The plaster-of-Paris cast is also to be preferred to the ambulatory bed described on page 733, because the children can be transported much more easily, which is of great advantage for the mothers and allows them to carry their children conveniently to hospital clinics or to physicians. After the rhachitic kyphosis has been overcome by two or three months' rigid treatment it is well to have the children wear some one of the above described corsets so as to prevent the development of lateral deformity.

Lordosis.—This condition involves the lumbar region in most cases and represents an exaggeration of the normal curves. It is as a rule a secondary static change that endeavors to compensate for kyphotic curves of the spine or to offset the permanent contraction of the hips found especially in hip disease and in congenital dislocation. The contraction developing in the course of psoas disease is compensated for by lumbar lordosis, provided the lumbar vertebræ have not become already fixed. Lordosis in the lumbar region may be secondary to paralysis not only of the extensors of the back, but also of the abdominal muscles, such as occurs, for instance, in anterior poliomyelitis and progressive muscular dystrophy. Paralysis of the extensors of the back is followed first by a paralytic kyphosis. When one of these patients makes an attempt to stand upright, the body will bend so far back that the centre of gravity is no longer in front, but behind. Gravity and tension of the abdominal muscles regulate the position to a certain extent. When the abdominal muscles are paralyzed, there is danger that the patient may fall over backward. For this reason he depresses the pelvis anteriorly and holds himself upright by means of the extensors of the back, but only within the limits that would ordinarily allow the trunk to fall forward without the action of the dorsal muscles.

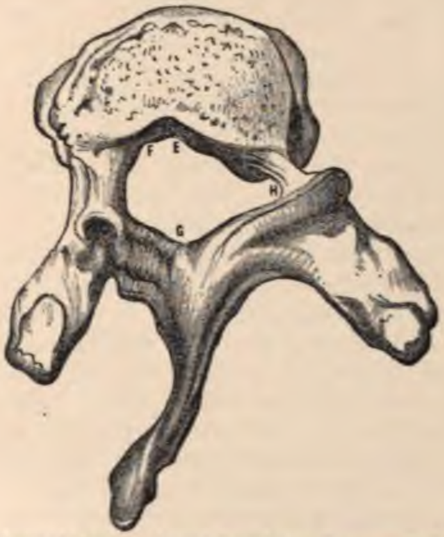
Lordosis may furthermore develop in spondylolisthesis as the result of rhachitis. The author means by this, complete dislocation of the last lumbar vertebræ onto the sacrum. This is usually due to loosening of the joint between these bones and the sacrum, and to secondary displacement forward of the vertebræ over the inclined plane of the sacrum. The preliminary loosening of the ligaments seems to be of congenital origin and due to absence of ossification in the interarticular portion of the fifth lumbar arch (spondylolysis). The lower articular process of the vertebra remains in place with the arch, whereas the upper one moves forward with the body. It is infrequent to have this displacement the result of destruction of the bones or joints due to tuberculosis or to arthritis deformans. Fracture of the articular process or of the arch is more likely to be the cause than the latter conditions. In a case reported by Hofbauer the condition was due to abnormal friability of the bones due to syphilis. If the displacement is so marked that the lower surface of the fifth lumbar vertebra leaves that of the upper sacral vertebra entirely, the lower or posterior surface of the former will be found in front of the upper or even in front of the second sacral vertebra within the pelvis. It may be held in place by fibrous tissue or synostosis in any of these places and prevented from becoming further displaced. The anterior displacement of the centre of gravity will be overcome by an increase of the lumbar lordosis.

Diagnosis.—The diagnosis will be made from the lordosis, the peculiar shortening of the chest (the thorax seems to have slid down between the flanges of the ilium), and the presence of dislocation, which can usually be appreciated by a rectal examination. Spondylolisthesis is of especial interest to the obstetrician on account of the changes in the shape of the pelvis. Most of the literature on this subject may be found in the obstetrical journals.

Prognosis.—The prognosis of lordosis is favorable because in the majority of cases the deformity does not become fixed.

Treatment.—The treatment is applied directly to the condition only rotation of the trunk to the left, and as the pelvis is fixed and the legs are held straight forward, this rotation takes place in the lumbar region. Perhaps the usual method of slanting the writing-paper has something to do with this rotation. Rotation in itself is sufficient to produce scoliosis, because the vertebral bodies in lumbar lordosis are placed in front of the axis of rotation, so that they become displaced toward the side of rotation, whereas the vertebræ of the dorsal section lying behind the axis of rotation are displaced in the opposite direction. Torsion therefore increases secondarily the curves which the spine has to assume in the attitude that children assume when writing. The length of time that the children are obliged to maintain these positions is the greatest element of danger. The above-described sequences develop gradually. The abnormal position becomes the customary average position, and finally it is no longer possible to assume a normal position either voluntarily or by passive measures. These methods of sitting while writing explain the frequent occurrence of primary habitual left convex lumbar scoliosis and right convex dorsal scoliosis. Other lateral curves are rarely observed due to habitual posture, and when present are, according to Lorenz, due to some position assumed in connection with rhachitis.

FIG. 304.



Change in shape of the spinal canal, broader on the convex side. (Hoffa.)

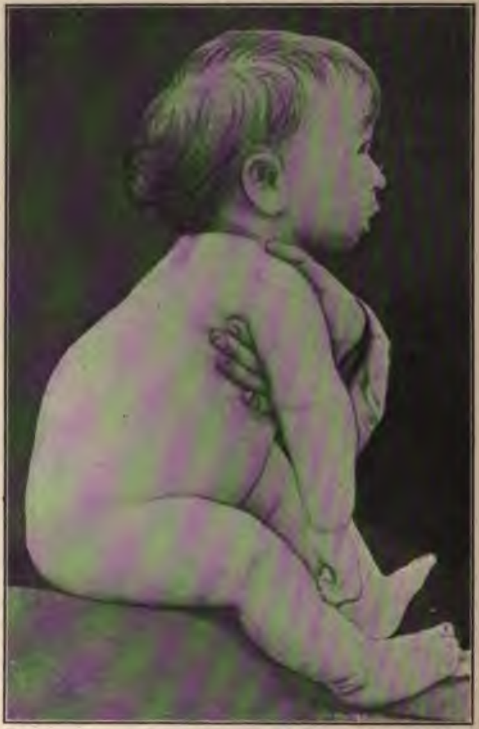
Besides the faulty position, the weight of the body is of etiological importance, because from the moment a curvature develops this has a tendency continually to increase the deformity. The effect of superincumbent weight becomes greater the greater the distance the summit of the curve from the axis of gravity.

All children that assume these faulty positions while writing do not necessarily suffer from scoliosis. The differences in the effect of the when a primary right convex dorsal scoliosis is compensated for by a left convex lumbar scoliosis and left convex cervical scoliosis.

Etiology.—The etiology of scoliosis is about the same as that of the conditions described in previous pages, although the author will be obliged to consider certain types where the etiology offers special points of interest.

Congenital Scoliosis.—This condition is extremely rare, only a few cases having ever been reported. They are supposed to be due to intra-uterine pressure, and Hirschberger has reported a case in Hoffa's clinic that was associated with congenital dislocation of the hip. Wagner reports the case of a viable child with congenital dislocation of the knee and hip and pronounced kyphoscoliosis. In the clinic at Breslau a case of congenital bilateral dislocation of the hips and knees was associated with scoliosis. In other cases there was asymmetrical development of the halves of the vertebral bodies. Mouchet describes a case in which the Röntgen rays showed the cause of a congenital dorsolumbar scoliosis to be an accessory piece of bone between the first and second lumbar vertebræ. Congenital scoliosis is also found in monstrosities, spina bifida, and fœtal rhachitis.

FIG. 300.



Rhachitic kyphosis. (Whitman.)

Rhachitic Scoliosis.—The curvatures occurring early in life are of rhachitic origin. They are produced by the weight of the head, and are aggravated by the habit of mothers of carrying children in their arms or leading them by the hand. The children are as a rule carried on the left arm while the right hand remains free. The left half of the pelvis of the child slides downward on the inclined plane of the forearm, and the child at the same time presses itself to the right against the mother. This produces a curvature of the entire length of the spine with the convexity to the left. Children are led as a rule by the right hand, so that they are obliged to raise their left, which again produces left convex scoliosis. Within a short time there develops a prominence of the ribs, such as will be mentioned in connection with postural scoliosis.

It is characteristic of the rhachitic curve that the middle and dorsolumbar sections of the spine are primarily affected. Postural scoliosis affects the dorsal or the lumbar column. After the rhachitis has disappeared the deformity becomes permanent and resists treatment. If taken at the right time, it is very amenable to treatment. The measures to be taken are chiefly those described in connection with rhachitic kyphosis. In older children with pronounced scoliosis the other methods of treatment spoken of in connection with postural scoliosis have to be considered. In the clinic at Breslau (Drehmann) successful attempts have been made to combat the condition with bandages, gymnastics, massage, and manual replacement, all of which tend to overcome the condition. This was done in such a way that after carrying out these methods of treatment for weeks and strengthening the muscles as much as possible, a plaster-of-Paris jacket was applied in as thoroughly corrected a position as possible; this allows certain gymnastic exercises, especially those with Wagner's apparatus. After fourteen days at the longest the plaster jacket is removed, and several weeks' use of calisthenics and massage follow. The plaster bandage is reapplied and the process repeated. Following these measures the height of the children increases and the deformity is diminished.

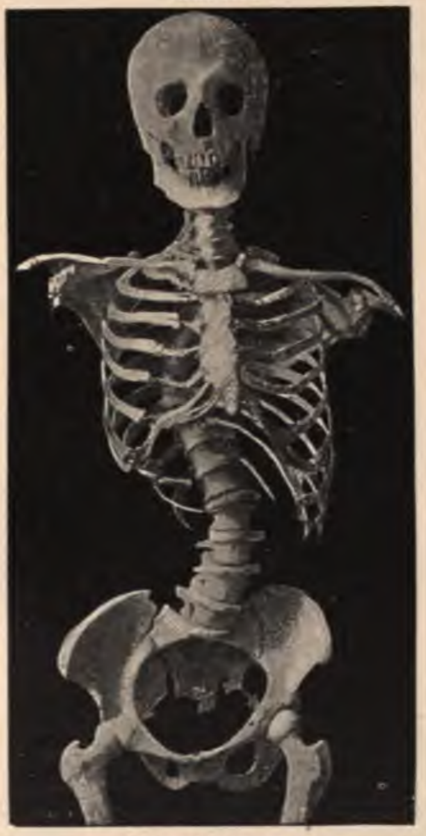
Static Scoliosis.—Static scoliosis is as a rule due to congenital or acquired shortening of one leg. The pelvis is lowered on the affected side, and to compensate for the shortening a convex lumbar scoliosis and compensatory dorsal scoliosis result. Static scoliosis does not become permanent very rapidly, because on sitting down the cause is removed and the spine assumes a more or less normal position. From about the twelfth year on there is a tendency for the deformity to become more fixed.

Certain authors claim that the percentage of static scoliosis is very high. (Vogt) Sklifosowsky found lengthening of the right leg 17 times in 21 cases. Fröhlich, on examining recruits, found that of 897 cases of scoliosis, 89 were due to inequality in the length of the legs. Other authors do not corroborate these statements. Lorenz examined 100 cases and found actual shortening only once; and Dolega examined

boy, although the latter frequently have very severe types, which is probably due to neglect on the part of relatives, who defer treatment until the deformity is well advanced.

The old explanations which sought to show that the curvature was due to unilateral muscular insufficiency and contracture on the other side (Delpech, Guérin, Eulenburg), or to insidious inflammatory processes in the vertebræ (Lorinser), or to exaggeration of the physiological scoliosis (Sabatier, Bouvier, Vogt), will be mentioned only. The latter theory is untenable, as shown by Lorenz, because according to this author there is no physiological scoliosis, the condition is imitated by the normal flatness of the left side of the dorsal vertebræ. According to the present views, the cause of postural scoliosis is an habitual faulty position assumed by the children when sitting during school hours, especially when writing. (Kocher, Staffel, Lorenz.) The faulty position is caused somewhat by the method of holding the writing-paper. According to Berlin and Rembold, the plane of the visual

Fig. 302.

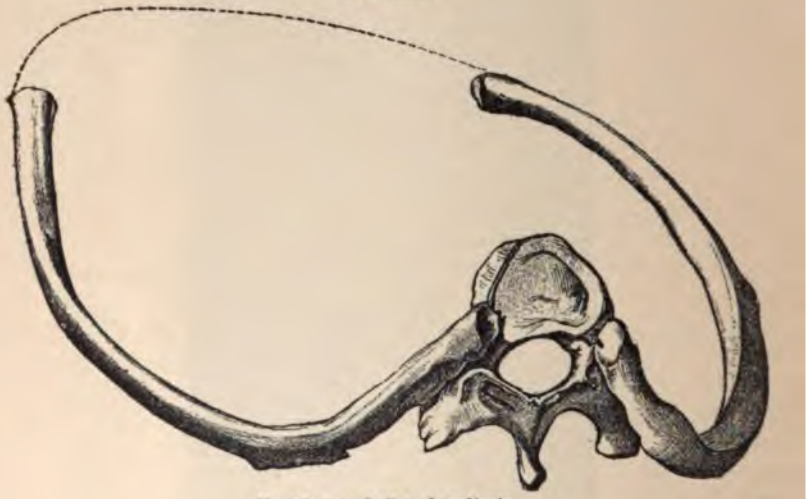


Scoliosis. (Dolega.)

axis should be at right angles to the lines of the paper; whereas according to Schubert, this plane should be parallel to the lines on the paper. According to the first author, the paper should be placed to the left at such an angle that the lower margin forms with the edge of the desk an angle of 30 degrees. The writing has about 30 degrees slant, and is therefore at right angles to the margin of the desk and to the visual plane if the pupil sits straight in front of the table. Any deviation of the writing changes the angle of the visual plane, so that it becomes necessary to turn the head to one side or the other.

Furthermore, children attempt to bear a certain proportion of the weight of the body on the arms, chiefly on the left, which is unemployed in writing. Schenk found that children prefer to hold their entire trunk to the left. The left forearm rests on the desk, while the writing-paper is pushed to the right. The writing slants more to the right toward the edge of the table, so that it is necessary to turn the head in a similar direction. This attitude necessitates a curve of the spine with the convexity to the left, a left convex complete scoliosis. The chief curve, however, is probably in the lumbar and lower dorsal vertebræ, while the upper thoracic segment remains straight. There is first primary left convex lumbar scoliosis, which, according to Lorenz, is the chief type of commencing postural scoliosis. Next in frequency is displacement of the trunk to the right. If the right arm is to be free, it must be lifted up with the shoulder, which can only be done by having the spine become curved in the sense of a right convex dorsal scoliosis. In this posture there is always a certain amount of torsion, which is chiefly due to the fact that only the hand of the left side and on the right side the entire forearm rest upon the table. This produces

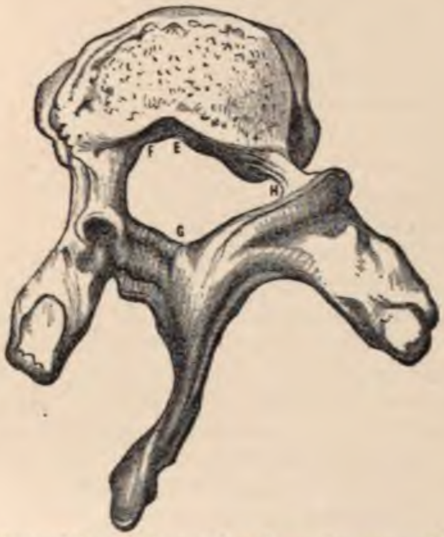
FIG. 303.



Vertebra and ribs of scoliosis.

rotation of the trunk to the left, and as the pelvis is fixed and the legs are held straight forward, this rotation takes place in the lumbar region. Perhaps the usual method of slanting the writing-paper has something to do with this rotation. Rotation in itself is sufficient to produce scoliosis, because the vertebral bodies in lumbar lordosis are placed in front of the axis of rotation, so that they become displaced toward the side of rotation, whereas the vertebræ of the dorsal section lying behind the axis of rotation are displaced in the opposite direction. Torsion therefore increases secondarily the curves which the spine has to assume in the attitude that children assume when writing. The length of time that the children are obliged to maintain these positions is the greatest element of danger. The above-described sequences develop gradually. The abnormal position becomes the customary average position, and finally it is no longer possible to assume a normal position either voluntarily or by passive measures. These methods of sitting while writing explain the frequent occurrence of primary habitual left convex lumbar scoliosis and right convex dorsal scoliosis. Other lateral curves are rarely observed due to habitual posture, and when present are, according to Lorenz, due to some position assumed in connection with rhachitis.

FIG. 304.



Change in shape of the spinal canal, broader on the convex side. (Hoffa.)

Besides the faulty position, the weight of the body is of etiological importance, because from the moment a curvature develops this has a tendency continually to increase the deformity. The effect of superincumbent weight becomes greater the greater the distance the summit of the curve from the axis of gravity.

All children that assume these faulty positions while writing do not necessarily suffer from scoliosis. The differences in the effect of the predisposing causes depend upon the time they have been active. The longer a child is obliged to sit and write, the quicker the faulty position will develop. One of the reasons why the condition is much more frequent in girls is the method of education, for besides the long hours at school, there are the hours at home when they are obliged to do housework or needlework, or to take piano lessons. On the other hand, the majority of games which boys partake in during the recesses and which strengthen their muscles are supposed not to be appropriate for girls, and are therefore prohibited.

Besides the above described etiological factors, insufficiency of the muscles is to be mentioned. The weakness existing at first is increased by the exhaustion following long hours of sitting. If a deformity is developing, it would take abnormally powerful muscles to maintain an erect position and overcome the curvature. The weak muscles present, even in the favorable cases, are only able to maintain a correct position for a few moments and then give out again immediately. Prolonged sitting is harmful even when the described pathological postures are not assumed. The greater weakness of girls and the ease with which they become tired explain why the disease is more common in this sex. Poor food and prolonged disease have a bad influence upon the muscles. This explains why scoliosis is so apt to develop after acute infectious diseases.

The consistence of the osseous system has a certain amount of influence upon the curvature. Rupprecht claims that 90 per cent. of the lateral curves are due to rhachitis, which is in all probability not correct. To be sure, late rhachitis may favor the development of deformity, but the frequent combination of scoliosis with other deformities proves there is apt to be some abnormal softness of the bones, or that they are more plastic than normal. In about 59 per cent. of the patients the feet are weak. (Roth, Redard, Heusner.) The rigidity of the bones varies considerably within normal limits, and depends upon the nature of the skeleton in general and upon the rapidity of growth. The children that grow rapidly show considerable tendency to scoliosis, and the rapidity with which girls develop further predisposes to this condition.

Heredity has probably some influence on the consistence of bone, and in about one-fourth of the cases hereditary predisposition has been found. (Eulenburg.)

An abnormally slight anteroposterior curve of the spine also predisposes to scoliosis, for children with flat backs are quite frequently affected, whereas those with hollow backs are hardly ever affected.

The fact that in the majority of cases a large number of the elements considered in the above etiology are active at the same time, and that only a few of the cases are due to purely habitual faulty position, led Dolega to subdivide the condition into postural scoliosis proper and constitutional scoliosis. Dolega applies the term postural scoliosis to children otherwise normal in whom the harmful influence of a faulty posture while sitting seems to be alone responsible for the deformity. He considers that the prognosis in these cases is more favorable because they may be cured by simple gymnastics. The other types of scoliosis in which the children show hereditary predisposition and are anæmic are less favorable in the opinion of this author.

It would be very difficult to give the pathological anatomy of scoliosis, although very excellent work has been done on this subject. (Albert, Lorenz, Nicoladoni, Hoffa, and Dolega.) The condition is as yet by no means clear, and therefore the opinions of these authors must be omitted and only a description given of the conditions as they are actually found.

The anatomical changes in the spine are the same no matter what the cause of the scoliosis. It has already been mentioned that in pronounced triple scoliosis there is rotation besides lateral flexion. The rotation produces a diagonal position of the vertebræ. The anteroposterior diameter that normally lies in the median line is pushed to one side and lies parallel to the normal with the posterior end somewhat nearer than the anterior.

Surgeons have to deal with growing plastic bones, and the forces that produce rotation have a certain amount of influence on the individual vertebræ, producing characteristic changes in them. The body appears displaced toward the peduncle on the convex side. The angle formed between the peduncles and the posterior surface of the bodies is changed. That on the concave side is enlarged, and the one on the convex side is diminished. The peduncle on the convex side is more or less anteroposterior, while the one on the concave side is more transverse, so that the shape of the vertebral canal is altered. The effect of a lateral curve is evident in the individual vertebræ, for the bodies become wedge-shaped. The apex of the edge, as pointed out by Albert, is not exactly to one side, but a little backward. The concave edges of these wedges may lie so closely together after the inteverte-bral disks have become atrophied that with advancing disease they become united. The lateral joints are also affected by lateral curvature. On the concave side the articular surfaces are pushed past each other to a greater extent and show some tendency to increase in size. The articular processes gradually atrophy. On the other hand, the articular surfaces on the convex side become smaller because they do not lie in contact except over a very small area. The changes in the shape of the vertebræ vary according to the position of the individual vertebræ in the different parts of the deformity. The curvatures succeed one another in such a way that it appears as if the spine had been wound around an axis extending from the occiput down to the sacrum. (Lorenz.) The curves are of varying extent—that is, the distance between the apex and the normal line varies in different portions, and the distance of the summit of the curves from the middle line indicates the degree of lateral displacement. The vertebræ near the summit of the curve are more distinctly wedge-shaped, and the forces that produce rotation have a greater effect in this region and produce more marked secondary results.

The place where the vertical axis crosses the curvature is termed the point of bisection, and the vertebra in this situation the nodal vertebra or the diagonal vertebra. At these points the curve in the spine and the rotation change from one side to another. These vertebræ are apt to seem spiral-shaped or screw-shaped, but aside from this they show no marked change. The anteroposterior diameter is in the sagittal line, although they may be rotated around this in marked cases as much as 90 degrees, so that the basal surfaces stand anteroposterior. It has already been seen that the posterior section of the spine becomes less displaced as the result of the rotation. It is important to remember this in estimating the amount of scoliosis from the position of the spinous processes. These may be comparatively little displaced, although the amount of curvature may be great. It is interesting to observe how the structure of the individual vertebræ adapts itself to the alteration of static conditions. All of the various points cannot be considered here, but it will be mentioned only that the spongy portion of the bone is considerably thickened on the concave side, where the amount of pressure is greatest. The convex side, on the other hand, appears distended. (Nicoladoni.)

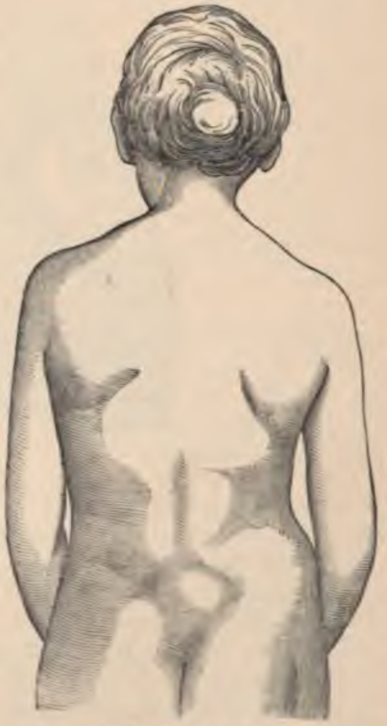
The secondary changes in the ribs have the greatest possible effect on the appearance of the body. These are attached to the transverse processes and to the arches, and are therefore obliged to adapt themselves to the displacement of the transverse processes, and must tend to become more anteroposterior on the convex side and transverse on the concave side. This abnormal position is somewhat compensated for by secondary curves of the ribs. The convex-sided rib shows an increased curve near the angle, and in severe cases it may be almost sharply kinked. The remaining portion of the rib is abnormally straightened. The curve of the ribs on the concave side, on the other hand, is considerably diminished up to the vicinity of the cartilage. Just before reaching the cartilage they became suddenly bent, and thus form a slight prominence just before reaching this articulation. The sternum is displaced from the median line toward the concave side.

Torsion tends to make the curvatures of the column that are anteroposterior appear flattened—*i. e.*, they tend to fall more and more in the frontal plane. When applying the name kyphoscoliosis to severe cases, it should be remembered that the kyphosis is not formed by the column itself, but by the prominent ribs. In very severe cases the ribs on the convex side may be in direct contact with the bodies of the vertebræ. The result of the lateral curve is to have the convex-sided ribs run diagonally downward from behind forward and diverge from each other, whereas the ribs on the concave side are almost horizontal and nearly touch. In severe cases they may be so close to each other that new joints form on the adjoining surfaces, as shown in the specimens in the Pathological Institute at Breslau. This pressure may be followed by severe neuralgia. In aggravated cases there may be asymmetry of the skull and pelvis, although the latter deformity can be completely absent, there being only a slight amount of tipping or twisting of an otherwise normal pelvis.

Ligaments, cartilage, and muscles undergo secondary changes. The changes in position and the alteration in shape of the internal organs, especially of the lung and liver, are of importance. The heart may be displaced, hypertrophied, and dilated. The aorta follows the curve of the spine, whereas the œsophagus is more apt to maintain its usual direction. The diaphragm, according to Bachmann, is usually considerably lower than usual, and the kidney on the convex side is lower down, while the kidney on the concave side is higher than normal. The one on the convex side adapts itself to the available space, and is more apt to be elongated, whereas that on the concave side appears rounded.

The clinical picture varies according to the severity of the above described condition. Although in a given case the symptoms tend to increase very slowly, it is of importance from a prognostic standpoint to subdivide the course into different stages that cannot, however, be distinctly separated one from the other. There are usually three stages besides the prodromal stage, during which all that is noticeable is a constant tendency to stand crooked. During this period the position may be voluntarily corrected. The children are able to square their shoulders by placing the muscles under proper tension. The movable scoliosis following this prodromal stage represents the period during which the patient is obliged to assume a faulty position. The trunk shows a certain amount of deformity that can only be corrected by asymmetrical action of the muscles. This faulty position may also be corrected by suspension or manipulation. In these early stages the treatment may be successful and complete recovery may follow. When allowed to continue, the deformity increases. Compensatory curves develop and the ribs become prominent. Contraction of ligaments and adduction of bones, with the development of synostoses, are followed by fixation of the scoliosis. In the second stage, that in which contractures have developed, the deformity can be overcome only partially, and in the third stage, that with fixed scoliosis (Fig. 306), suspension corrects only the displacement of the upper portion of the trunk and has but little effect

FIG. 305.

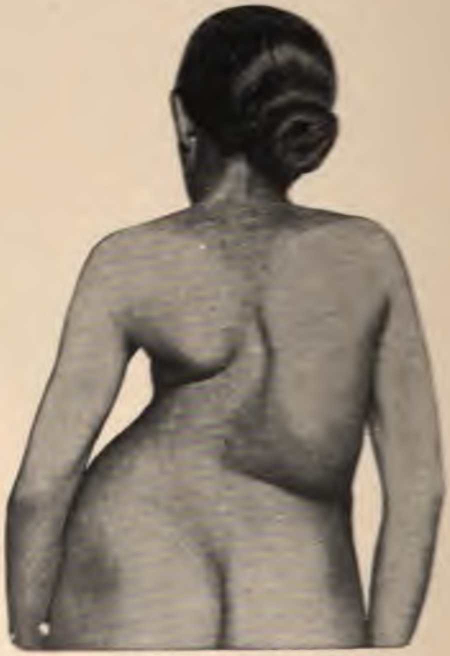


First degree of scoliosis.

upon the curvature itself. In this stage there will be compression
the lung, displacement of the internal organs, and evidence of pre
ure upon nerves. Scoliosis need by no means progress until th
stage has been reached, and may in many cases remain stationary lo
beforehand.

Symptoms.—The symptoms of scolioses are direct and indire
Direct symptoms are those referable to the spine itself, such as devi
tion of the spinous processes and prominence in the lumbar regi
produced by the transverse processes on the convex side under t
influence of rotation. This deformity is analogous to the prominence

Fig. 306.



Third degree of scoliosis.

the ribs. It has already been mentioned that the amount of displac
ment of the spinous processes need by no means indicate accuratel
the amount of curvature.

Limitation of motion may be a valuable sign in the early stag
because lateral flexion may be more toward the concave side th
toward the convex side even when there is but a slight amount
contraction.

Generally speaking the symptoms known as indirect symptoms a
more pronounced. They are due to the fact that various organs mo
or less closely connected with the spine accompany the latter, and a
therefore displaced. In this connection, first may be mentioned th
ribs. Rotation is evident quite early from the prominence of the ri

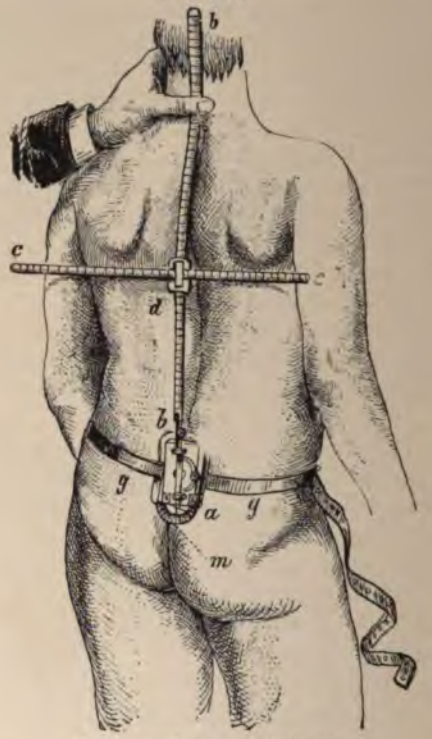
on account of the length of these bones. It will be noted much earlier than rotation in the lumbar region, where the amount of torsion has to be great before deformity due to the transverse processes becomes evident. The difference in height of the shoulders is also secondary to displacement of the ribs. When the deformity affects the upper section of the chest, the shoulder on the convex side will be higher; therefore the right one as a rule. The shoulder-blade on this side has a certain amount of influence in this connection. It lies over the prominent ribs and is therefore very prominent itself. The internal margin of the scapula lies in the region of the angle of the ribs, and therefore becomes slightly moved away from the median line. The ribs, as has been seen, become more and more sagittal from the prominent region downward, and the scapula therefore rotates toward the sagittal plane. The shoulder-blade on the concave side, on the other hand, is approximated toward the spinous processes corresponding to the direction of the ribs in this region that lie more in the frontal plane. The asymmetry of the shoulders is marked quite early in asymmetry of the contour of the neck.

Scoliosis in the lumbar region is characterized by differences in the hips. That on the concave side is prominent, whereas the one on the convex side is flattened.

All of these asymmetrical conditions are important symptoms. The sacral triangle, normally an equilateral triangle, will be asymmetrical in lumbar scoliosis, and the so-called triangles of the waist, formed by the lateral outline of the trunk and the arms while hanging at the side, is of importance, because any asymmetry will show changes in the relation of these two triangles. Although the signs of scoliosis are marked in severe cases, the early symptoms are at times but slightly noticeable. Attention is attracted to the condition by a high shoulder or a high hip.

For the purpose of examination the patient should be stripped to the waist and any asymmetry carefully noted, the position of the shoulders and of the shoulder-blades, the relation of the trunk to the pelvis, the relation of the triangles of the waist, prominence of the ribs, or prominence due to rotation. The patient should stand with the heels together and in as normal position as possible. An examination should be prolonged, so as to allow the spine to assume its habitual position, for the patients are apt to stand in a forced attitude during the first moments of the examination. If needs be, a few exercises may be done so as to overcome this forced attitude. After having the patient cross the arms over the chest in front, the back should be examined: first while standing erect, and then while bending forward; next the lateral mobility should be taken and an endeavor made to overcome the deformity by suspension or by manual pressure. Most modern orthopædists demand that the scoliosis should be accurately measured, so as to be able to judge of the success of treatment. This problem has not been solved in spite of the many methods of measuring that have been recommended. (Zander, Beely, Schulthess, and v. Heinleth.) Even the x-rays do not furnish the information that Hoffa and Joachimsthal hoped that they would. Generally speaking, an ordinary tape-measure is sufficient or the scoliometer recommended by Mikulicz. (Fig. 307.) Stereoscopic photographs are valuable in this connection.

Fig. 307.



Scoliosometer. (v. Mikulicz.)

With left convex lumbar scoliosis the right triangle of the waist will be increased, whereas the left will be diminished or completely obliterated. The right crest of the ilium is more prominent than the left. The spinous processes reach the median line again at about the angle of the scapula and rotation is not marked. The right-sided prominence of the ribs due to the compensatory curve in the dorsal region may appear earlier and be more marked than the left-sided fold in the lumbar region due to rotation, which is the reason why this form of deformity is very apt to be considered a primary right convex dorsal scoliosis.

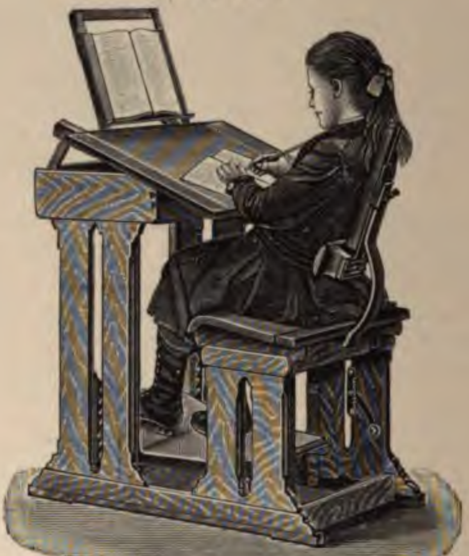
Sometimes a left convex lumbar scoliosis develops into a left convex complete scoliosis; then the fold due to rotation in the lumbar region and the prominence of the ribs will both be on the left side.

Primary right convex dorsal scoliosis is first noted on account of the slight lateral prominence of the ribs and flattening of the right side of the chest, while the left front of the chest is more prominent than the right side. The shoulder-blades show the deformity described above. As soon as the spinous processes begin to deviate from the median line compensatory curves appear and a left-sided fold, due to rotation in the lumbar region. It should, however, be remembered that torsion may be very slight, and be overlooked because of the moderate development of these compensatory curves. The right triangle of the waist deepens and the hip is more prominent. The left one becomes flattened. Later the entire trunk is displaced to the right, and the right arm on hanging down does not come in contact with the hip at all, so that the triangle of the wrist is open below. The left hip will now be more prominent. Both of these types of scoliosis are observed with about equal frequency. Primary left convex lumbar scoliosis may be somewhat more frequent than primary right convex dorsal scoliosis. (Lorenz.) Compared with these two the other types are uncommon.

Prognosis.—The prognosis of scoliosis is always grave, and depends upon the variety, the duration, the age of the patient, and the energy with which treatment is followed out. Although the results are very favorable when treatment is commenced early and continued faithfully, it will be difficult or even impossible to obtain any improvement whatever in cases that have become fixed, and in these cases the symptoms due to pressure, such as neuralgia, etc., will have considerable influence upon the general condition of the patient.

Treatment.—The treatment of scoliosis generally speaking is prophylactic. The causative factors that have been considered in connection with the etiology of scoliosis should be avoided as much as possible. Rhachitis should be energetically combated. Young children should not be allowed to sit up too long, and should not be carried on the same arm for too great a length of time, and should not be habitually led by the same hand. Children that are naturally weak should be kept recumbent as much as possible. At night they should have only a very low pillow and if possible be kept upon a hair mattress. Later, attention must be paid to the symmetrical development of bones and the muscles by carefully regulating the athletics. The sitting posture, especially in school and at home, should be carefully watched, for improperly constructed benches at school and the chairs at home are frequently responsible for the faulty position. (Fig. 308.) The height of the chair should correspond to the length of the leg and the depth of the seat to the length of the thighs. The seat itself should be somewhat higher in front than farther back. The distance from the seat to the table should correspond to the distance of the elbows from the seat, and should be made 3 to 5 cm. greater than this because the elbows are lifted a little while writing. The desk itself should slant at an angle of 15 degrees. The distance between the posterior edge of the desk and the anterior edge of the seat is important. If this is too great, the child is obliged to bend forward, or forward and sidewise, which in the latter case favors scoliosis and also has an injurious effect upon the eyes. The seat should be pushed up to the desk until the distance between the back of the chair and the margin of the desk is but little more than the sagittal diameter of the trunk. If the back is to be of service, it should be inclined backward at an angle of about 10 degrees and reach up as far as the shoulder-blades. The back of the chair should correspond to the normal curvatures of the lumbar portion of the spine. This relation of the chair to the table applies only while sitting and writing, and a good school-desk and chair should be so arranged that by some simple contrivance the seat can be so changed as to enable the child to stand without bending the knees or hips.

FIG. 308.



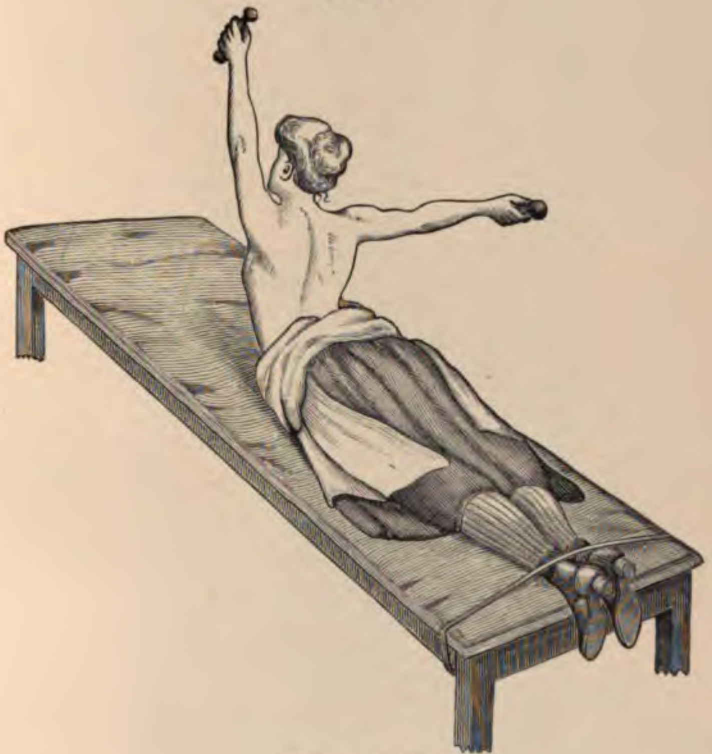
School desk. (Holscher.)

It has been seen that the position of the head is influenced by the slant of the writing and the direction of the line upon which the child writes. There is least tendency to turn the head sidewise when the lines are parallel to the margin of the table and when the writing is at right angles to the same. This only happens with vertical writing and not with slanting, and for this reason it would be far better to introduce the former in all schools. Children that show any tendency to scoliosis should by all means be taught to use the vertical system.

If there is already evidence of scoliosis, treatment should commence immediately and very energetically. The author will not present all the methods that might be applied in this direction, but will confine himself to those of a more general nature.

It is of great importance to improve the general condition. Anæmia, rhachitis, and disturbances of nutrition should be carefully attended to. Delicate children with progressing scoliosis should be taken from school, or the hours should be so arranged that they sit in one position as little as possible. Sometimes living in the country or at the seashore has a beneficial effect. In the early stages, and still more in the prodromal stage, it is desirable to impress upon the patients the importance of correcting their faulty position so that they may learn to assume a normal posture by active muscular action. The children should be continually reminded and their vanity in this direction stimulated as much as possible. An effort should be made to strengthen the muscular system by appropriate athletics and massage, so that the children become sufficiently strong to hold themselves erect. In the later stages the positions due to contracture and beginning ankylosis must be combated. The spine should be immobilized as much as possible and rotation limited. With present methods it is not possible to restore the normal conditions, and the surgeon is therefore forced to be content with even slight improvement or with a stationary

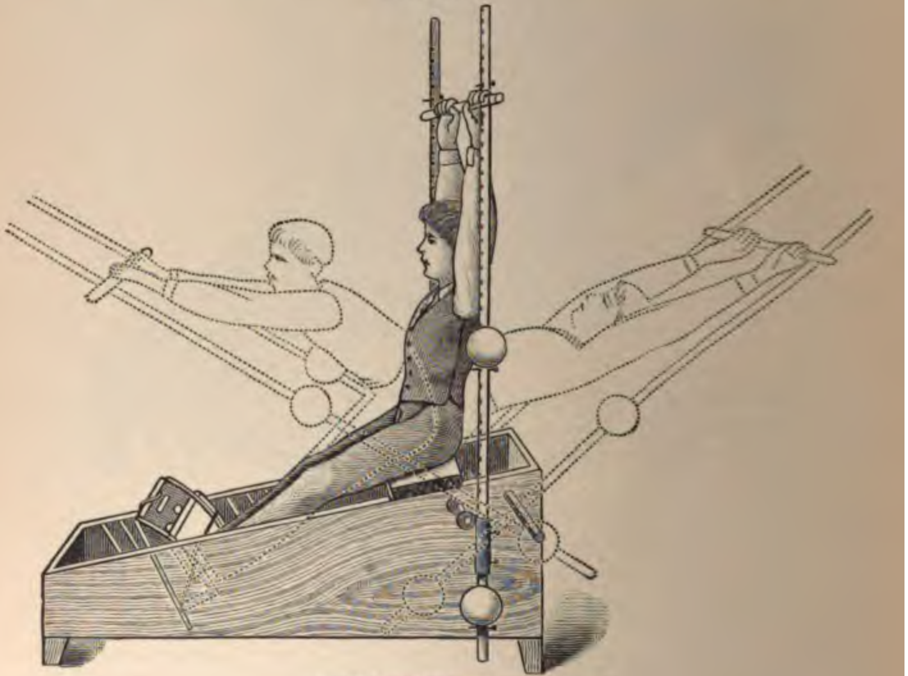
FIG. 309.



Gymnastic table.

condition. The treatment may be subdivided in the following manner: 1. General and special gymnastics (active redressement and massage). 2. Immobilization of the spine by (*a*) suspension, exercising; (*b*) passive, methodical correction (redressement). 3. Portative supporting apparatus; 4. Recumberant apparatus. Exercises are most important with any method of treating scoliosis and in any stage of scoliosis. The surgeon should always insist upon these, because certain of the other therapeutic measures are distinctly injurious if not combined with exercises. In patients with lateral curvature the exercises should involve the entire muscular system, because all of the muscles, and not only the muscles of the back, are apt to be weak. (Fig. 309.) Calisthenics and exercises with dumb-bells and rods should be performed under supervision. The rules and regulations for this branch of treatment are given in works of v. Mikulicz, Tomasczewski, Schreber, Schildbach, and Angerstein. Exercise with simple resisting apparatus is also of value.

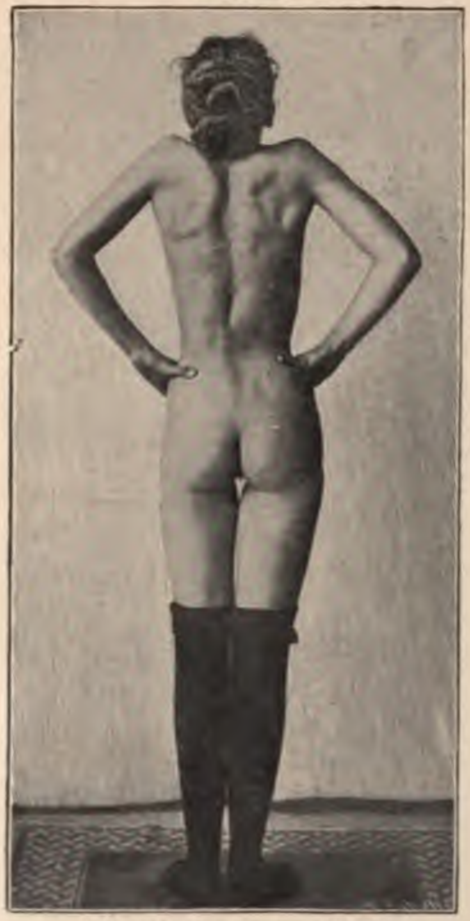
FIG. 310.



Beely's rowing apparatus.

Besides these general gymnastic exercises special attention should be paid to the muscles of the back themselves. These exercises may be symmetrical and affect both sides evenly or they may be asymmetrical. The former include the exercises that flex and extend the trunk and rotate the back The exertion may be increased by extending the hands or by using light dumb-bells or rods. By placing a rod behind the back and through the elbows the children are forced to stand erect. Exercises performed while lying down are of especial value. The feet are tied to a firm bench that is evenly padded and then the trunk is raised from the table. The extensors of the back and the rotators of the front may be strengthened in this way. These exercises may be combined with extension of the head and exercises with the arms with or without the aid of dumb-bells, etc. The exercises may be symmetrical or asymmetrical. Beely's rowing apparatus has proved of especial value. The muscles of the back are obliged to do considerable work and the curvature of the spine is corrected at the same time. (Fig. 310.) Stretching the spine may be achieved by

FIG. 311.

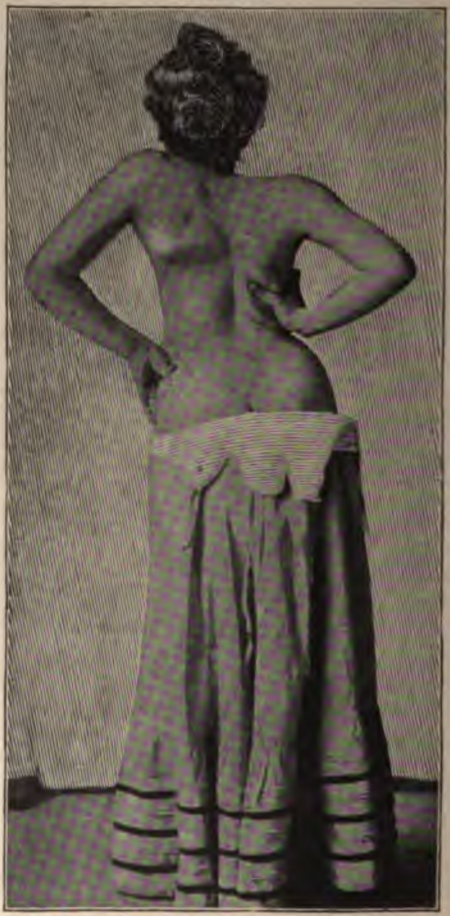


Active extension exercise. (Hoffa.)

having the patient place the hands upon the hips and then extend the spine as much as possible. (Fig. 311.)

The unilateral or asymmetrical exercises are not done for the purpose of combating unilateral muscular atrophy, as was formerly supposed, but represent active corrective exercises that force the spine to assume a position differing as radically as possible from that of the pathological condition. These exercises should be done only under careful supervision, for in complicated cases it may happen that one curve is favorably influenced, whereas another may be increased. A great many of the unilateral exercises have this fault, and the author will therefore mention only two of the most effective corrective exercises. One of these is evident from Fig. 312, and may be used especially in dorsal scoliosis or in complete scoliosis. The second, depicted

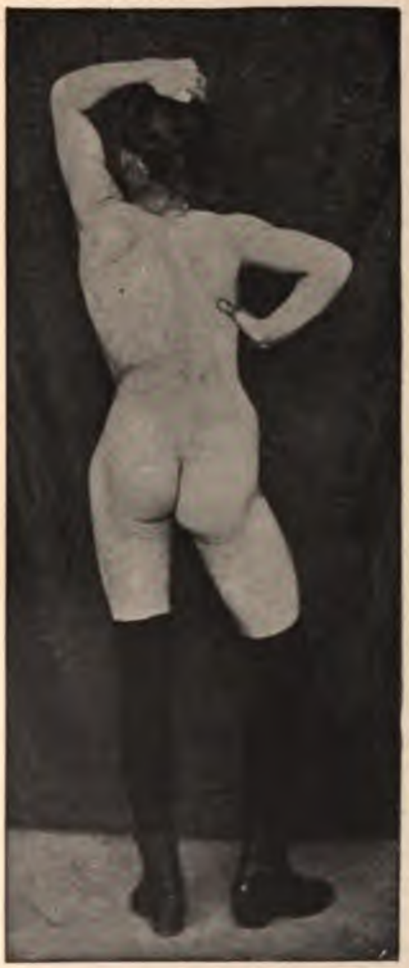
FIG. 312.



Active replacement exercises. (Hoffa.)

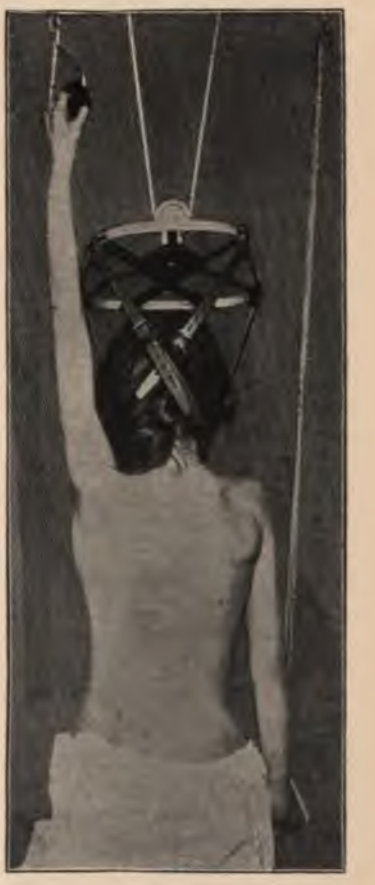
in Fig. 313, represents a complete change in the curve of the spine in the most common variety of double scoliosis. The patient places the abducted right leg forward. The left hand is placed on the head and the right over the prominent ribs. At command, the right leg is flexed at the knee and hip. The child then bends the trunk to the left and extends the left elbow upward as much as possible and to the left, whereas the right arm brings pressure over the deformed ribs.

Fig. 313.



Active replacement exercises. (Hoffa.)

Fig. 314.



Wagner's suspension apparatus.

Flexion of the abducted leg changes the lumbar scoliosis, and the other motions change the dorsal curve into the opposite variety. It is very important in all of these exercises to have the children learn to perform them accurately, and they should also be taught, especially in the exercises upon the table, to breathe deeply. They should do this at command.

The muscles should also be strengthened by energetic massage. The extensors of the back should be rubbed from above downward at either side of the spine, and the latissimus dorsi and trapezius should be rubbed in the direction of their fibres. These muscles should then be kneaded, and finally they should be slapped. This is done by holding both hands at right angles to the spine in a position of semipronation. By supinating the hands completely the finger-tips touch the back suddenly and elastically.

With an early scoliosis exercises and massage will be sufficient; but when the condition is well advanced, other means should be used to combat the increasing rigidity and rotation. In these stages passive immobilization and corrective exercises should go hand-in-hand with strengthening of the muscles. All methods that aim only at correction and achieve this at the expense of the muscles are to be condemned. They place the spine, of course, in a better position, but the inactivity of the muscles allows them to degenerate. Treatment of scoliosis with Sayre's plaster-of-Paris corset therefore is to be condemned, as well as correction under an anæsthetic, such as has recently been recommended. In the first place, this latter procedure is not without danger and demands prolonged treatment with plaster-of-Paris jackets.

Of the measures that tend to extend and immobilize the spine, suspension should first be mentioned. Hanging exercises on flying rings, the horizontal pole, and the diagonal and horizontal ladder are also recommended. Besides this, exercise on an apparatus especially constructed for the treatment of scoliosis is to be recommended.

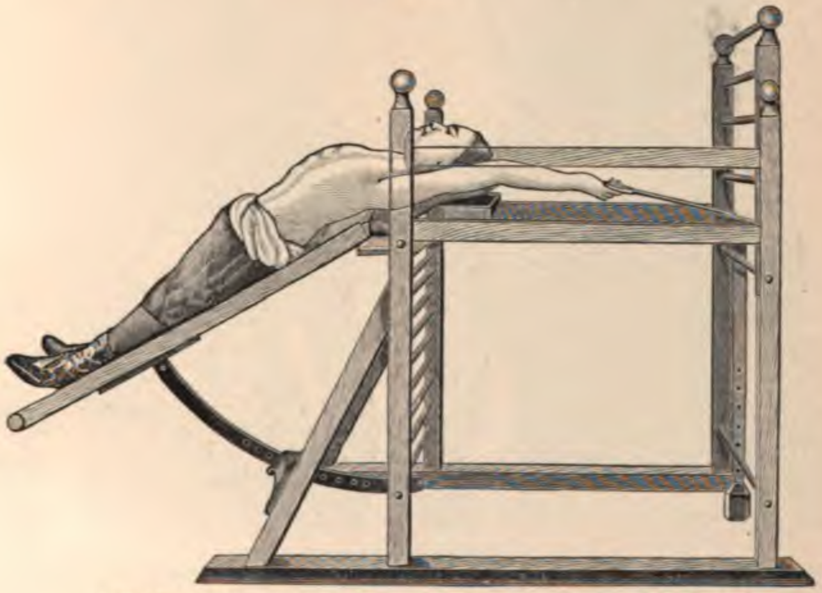
Wagner's apparatus has been received with much favor. The head is fixed in a sort of Glisson sling, which, however, allows of motion in all directions on account of the ball-and-socket joint attached. The patients should swing and rotate the trunk or swing the legs and try to replace the deformed spine by uneven upward traction.

The use of an inclined plane is very extensively advocated. There should always be some arrangement so that the head may be suspended at the upper end. This apparatus is of especial value for exercises that tend to overcome special points in the deformity. (Hüsner and v. Mikuliez.) Suspension is supposed to extend the curved spine and overcome the deformity. Manual replacement by applying direct pressure to the prominent portion of the curve serves the same purpose, and may be done while lying down or while suspended, either by the hands or by some one of the apparatus invented for this purpose. Rollers of various sorts with pulley attachments have been used for this purpose, especially by v. Mikuliez. (Fig. 315.) Pressure-pads have also been used with the idea of keeping the corrected position as long as possible. Generally the pressure-pad is combined with suspension, as in the apparatus constructed by Hoffa and modified by Schede, Dolega, and Schulthess. It is questionable whether any of these machines give permanent results. They should, however, be tried in severe cases.

In immobilizing the joints the pendulum principle has been kept in mind in constructing apparatus that is very effective. (Krukenberg, Handeck, Schulthess.)

It is not easy to judge of the amount of success, for it frequently happens that apparent improvement is offset by damage to the muscular system which leaves the patient in a condition no better than that before treatment was instituted. This applies especially to braces, the value of which is much overrated. When used, they should be combined with exercises. No brace is able to change the bony deformity, because the patients could never withstand the amount of pressure necessary. A brace is only able to retain the position that can be assumed by active correction or in aggravated cases by immobilization. The arm crutches may support a certain part of the body weight and furnish permanent suspension. If possible, the brace should be made so that the muscles are not completely without function.

FIG. 315.



Roller combined with inclined plane; weight and pulley. (v. Mikulicz.)

Schulthess considers that all corsets are to be condemned and has seen only disastrous effects from their use. Hoffa, Tausch, Joachimsthal, Kölliker, Vulpius, and Lange consider, on the other hand, that corsets are an extremely valuable aid. According to the views held in the clinic at Breslau, the use of a stiff corset in the early stages of scoliosis is to be condemned. When the curvature shows a tendency to increase in spite of energetic massage and exercises, it may be necessary to furnish the patient with some sort of a brace, especially during school hours. This apparatus should allow of a certain amount of motion, however, and the author as a rule prefers **v. Mikulicz's** brace, which is an improvement on Nyrop's.

Mikulicz's apparatus (Fig. 317) consists of a pelvic band with Hessing's buckles. A dorsal upright is fastened to this, which supports the crutches and the pressure-pad. This apparatus extends the spine while the pad itself presses upon the prominent ribs. It is an advantage with this apparatus that the anterior portion of the body remains perfectly free, and therefore the brace does not interfere with respiration. Besides, the brace is extremely elastic.

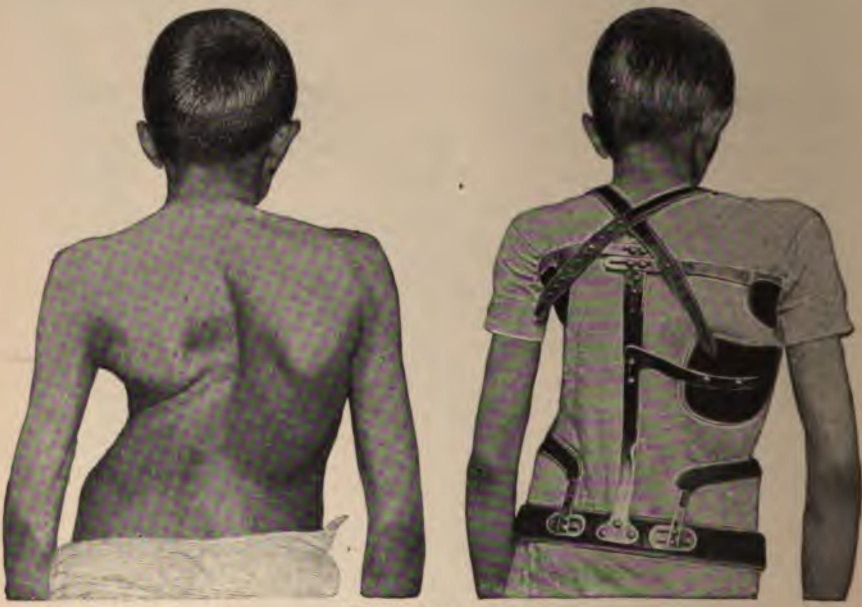


FIG. 316. FIG. 317.

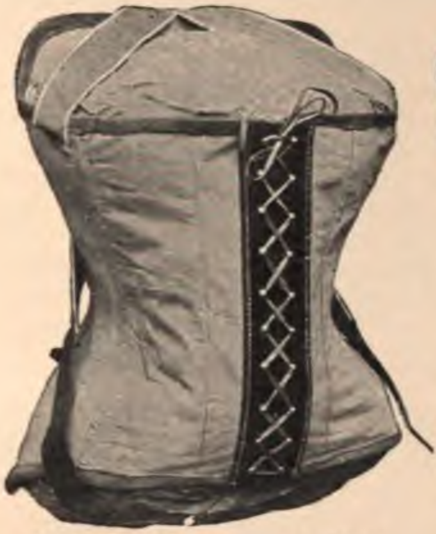
Mikulicz's apparatus.

Hessing's corset is extensively used, and is of value, not only in overcoming the deformity, but also from a cosmetic standpoint. The author considers the alterations in this apparatus that have been suggested by Vulpius and which make the corset stiff, to be of uncertain value, chiefly because the chest is completely surrounded and the influence upon the growth of the thorax is detrimental.

For patients with moderate means a celluloid corset may be made quite serviceable by cutting it up the back and putting in a lacing. The spine is not completely immobilized in this way (Figs. 318 and 319), and the corset is best laced with elastic, so as to interfere as little as possible with respiration.

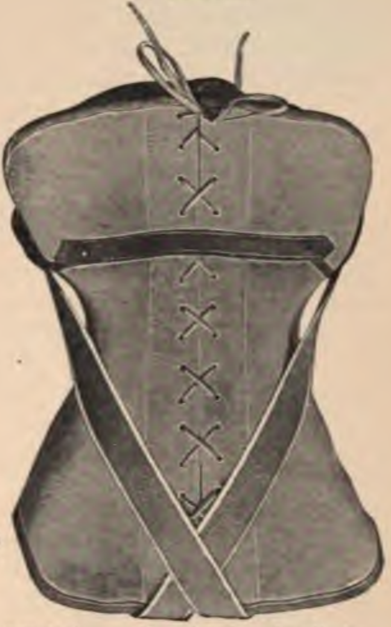
In aggravated cases the author employs stiff corsets and uses the material described on page 740. When there is severe neuralgia, these jackets may be of great value in overcoming the pain. All braces should be applied while the patient is suspended, and in all cases of fixed scoliosis, massage and exercises should be used in addition to the corset.

Fig. 318.



Celluloid corset for treatment of scoliosis.

Fig. 319.



Celluloid corset for treatment of scoliosis.

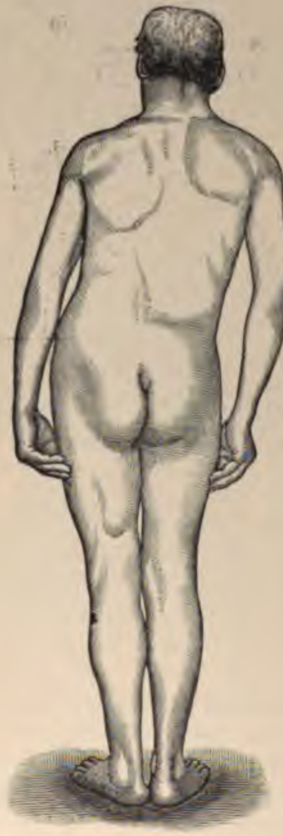
Neuromuscular Scoliosis (Ischias Scoliotica).—With sciatica it is not uncommon to have marked curvature of the spine. Gussenbauer called attention to this subject in 1878, and advocated the name neuromuscular scoliosis. Kocher in the following year suggested the name ischias scoliotica. It is most common to have so-called heterogeneous scoliosis in connection with sciatica. The trunk, especially the dorsal trunk, is inclined to the opposite side, whereas the lumbar column and the lower dorsal vertebræ show a curve with the convexity toward the diseased side. In homologenous scoliosis the trunk is displaced toward the affected side and the convexity of the lumbar column is toward the healthy side.

Of late, cases of alternating scoliosis, in which the patient shows at one time heterogeneous and at another time homologous scoliosis, have also been reported. A patient thirty-five years of age had suffered for one year from right sciatica and presented for several months a homologous scoliosis. (Fig. 320.) For weeks at a time he is perfectly straight. The pain increased in the right hip and leg, and on arising in the morning he is bent first to the right. After some time he becomes tired and then supports himself on his hands and knees, just as a patient with Pott's disease. The body is immediately flexed to the opposite side and typical heterogeneous scoliosis appears. (Fig.

321.) There is no point of tenderness on the left side. On sitting down the scoliosis disappears, although pressure upon the right sciatic nerve immediately produces homologous scoliosis.

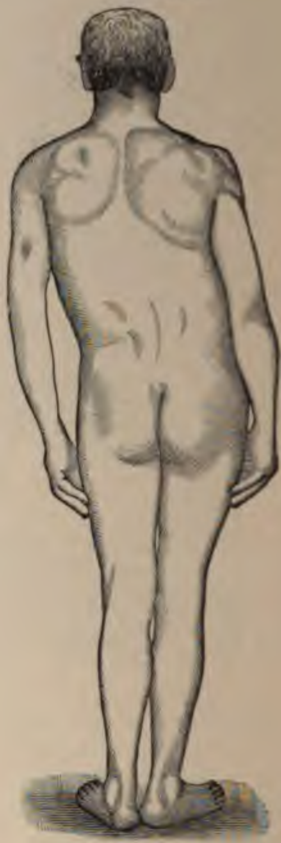
As a rule there is some bending forward of the trunk, producing a kyphosis of the lumbar column, besides the lateral curve. Albert and Charcot consider that these curves are the result of instinctive removal of weight from the affected leg. Baer considers that the scoliosis is of static origin, and the patient is supposed to endeavor to avoid pain by extending or bending the hip- and knee-joints. Vulpius considers the condition to be a reflex muscular spasm. Ehret calls attention to the position of the legs in patients with fresh attacks of sciatica that are in bed. He showed with anatomical preparations that the sciatic nerve was relaxed by abduction, rotation outward, and slight flexion of the thigh combined with a slight amount of flexion at the knee-joint. Most patients with acute attacks of sciatica assume this position

FIG. 320.



Homologous scoliosis.

FIG. 321.



Heterogeneous scoliosis.

in bed. On getting up, sciatic scoliosis is supposed to develop as compensation for the position assumed for the purpose of relaxing the nerve. Although this explanation is very plausible, it does not explain the other varieties of scoliosis, for instance, the alternating. Not infrequently there is considerable displacement of the trunk contrary to the laws of gravity. Besides, in hip disease very similar deformity should be expected. The author believes that Vulpius' opinion is correct, and that sciatic scoliosis is largely due to contracture produced by muscular spasm. These spasms, to be sure, may be partly due to the patient's desire to relax the sciatic nerve.

Treatment.—The treatment of neuromuscular scoliosis is the treatment of the original sciatica. The author has had considerable success, however, in combating the scoliosis directly by braces, suspension, and exercises. Massage of the back and legs and careful active and passive motion will gradually overcome the contracture. Beely recommends his rowing apparatus in conjunction with a brace, because in this machine not only is the scoliosis straightened, but the sciatic nerve also is stretched. The author has repeatedly seen beneficial results from the use of this apparatus.

INDEX.

- ABSCESS at angle of jaw, 83
  - Abscesses, branchiogenic, of neck, 123
    - of chest-wall, 454
      - acute, 454
      - cold, 454
        - treatment of, 454
      - empyema necessitatis, 454
      - perforating, of lung, 454
      - peripleuritic, 454
    - of lungs, 506
      - diagnosis of, 507
      - perforating, 454
      - prognosis of, 508
      - symptoms of, 507
      - treatment of, 508
    - of neck, 76
    - peripleuritic, 454
    - of supraclavicular fossa, 84
    - tuberculous, of neck, 85
    - of vascular space, 83
      - prognosis of, 84
      - treatment of, 84
- Accessory goitre, 310
  - thyroid gland, anterior, 313
    - endolaryngeal, 313
    - inferior, 311
    - posterior, 312
    - superior, 313
    - tracheal, 313
- Acinous carcinoma of the mammary gland, 585
- Actinomycosis of breast, 575
  - of larynx, 209
    - treatment of, 210
  - of lung 522
    - diagnosis of, 524
    - symptoms of, 523
  - of neck, 86
    - diagnosis of, 87
    - prognosis of, 87
    - treatment of, 88
  - of spine, 755
    - diagnosis of, 756
    - prognosis of, 756
    - symptoms of, 756
    - treatment of, 757
  - of thoracic wall, 458
    - diagnosis of, 459
    - prognosis of, 460
    - symptoms of, 459
- Actinomycosis of thoracic wall, treatment of, 460
  - of thyroid gland, 346
- Adenoma of mammary gland, 580
- Aërocele, 147
  - diagnosis of, 148
  - etiology of, 147
  - symptoms of, 148
  - treatment of, 148
- Air-passages, burns of, 162
  - diagnosis of, 163
  - treatment of, 163
  - foreign bodies in, 163
    - diagnosis of, 169
    - pathological changes, 165
    - prognosis of, 169
    - treatment of, 171
  - operations on, 250
- Aneurism of aorta, 455
  - of neck, 66
    - arterial, 66
      - of common carotid, 66
        - of beginning of, 70
        - diagnosis of, 68
        - prognosis of, 68
        - treatment of, 68
        - of upper part of, 68
      - of external carotid, 70
      - of innominate, 70
        - diagnosis of, 71
        - treatment of, 71
      - of internal carotid, 70
      - of subclavian above collar-bone, 72
        - prognosis of, 72
        - treatment of, 72
      - of vertebral artery, 72
    - arteriovenous, 73
      - of common carotid and internal jugular, 73
        - prognosis of, 74
        - symptoms of, 73
        - treatment of, 74
      - of external carotid and internal jugular, 75
      - extracranial, of internal carotid, 75
      - of subclavian vessels, 75
    - traumatic, 66
  - of thoracic aorta, 541
    - treatment of sac contents, 542

Aneurism of thoracic aorta, treatment of vessel-wall, 542
Angioma, cavernous, 455
    of neck, 130
      prognosis of, 131
      symptoms of, 131
      treatment of, 131
  of mammary gland, 580
  simplex of neck, 130
Aorta, thoracic, aneurism of, 541
      treatment of sac contents, 542
        of vessel-wall, 542
Arches of vertebræ, isolated fractures of, 683
        diagnosis of, 683
        treatment of, 683
Areola, diseases of, 564
Arteries in neck, injuries of, 40
      symptoms of, 40
      diagnosis of, 41
      prognosis of, 42
      treatment of, 42
    ligation of, 44–55
      common carotid, 44
          at level of cricoid cartilage, 44
          between heads of sternomastoid, 44
      external carotid, 49
      innominate, 54
        technic of, 54
      lingual, 50
        technic of, 51
      subclavian in supraclavicular fossa, 53
          technic of, 54
      vertebral, 51
        Chassaigne's method, 52
        Fray's and Kocher's method,
        Helferich's method, 53
        Kocher's method, 52
        Mikulicz's method, 52
Artery, carotid, common, arterial, aneurisms of, 66
          of beginning of, 70
          diagnosis of, 68
          prognosis of, 68
          treatment of, 68
          of upper part of, 68
      arteriovenous, aneurisms of, 73
          prognosis of, 74
          symptoms of, 73
          treatment of, 74
    external, arterial aneurisms of, 70
      arteriovenous aneurisms of, 75
    injuries of, 44
    internal, arterial aneurisms of, 70
      extracranial arteriovenous aneurisms of, 75
  innominate, arterial aneurisms of, 70
        diagnosis of, 71
        treatment of, 71
  subclavian, arterial aneurisms of, 72
Artery, subclavian, arterial aneurisms of, prognosis of, 72
        treatment of, 72
    arteriovenous aneurisms of, 75
    injuries of, 43
      prognosis of, 43
      treatment of, 43
  thyroid, ligation of, in treatment of goitre, 339
  vertebral, injuries of, 43
      diagnosis of, 43
      prognosis of, 43
      treatment of, 43

BEELY'S rowing apparatus for scoliosis, 792
Benign tumors of chest-wall, 461
    of larynx, 225
      diagnosis of, 228
      prognosis of, 228
      symptoms of, 228
      treatment of, 229
    of lung, 528
    of mediastinum, 537
Blood-cysts of neck, 126
    diagnosis of, 127
    prognosis of, 128
    symptoms of, 127
    treatment of, 128
Boils of chest-wall, 452
    treatment of, 452
  of neck, 75
Brachial plexus, injuries of, 64
Branchial cleft outgrowths of skin of neck, 23
          etiology of, 23
    second, fistula of, 19
        complete, 19
        incomplete, 19
          external, 19
          internal, 19
Branchiogenic abscesses of neck, 123
  cysts of neck, 120
      diagnosis of, 122
      prognosis of, 122
      symptoms of, 122
      treatment of, 122
  tumors of neck, 123
Breast, actinomycosis of, 575
  cystadenoma of, 571
  cystic disease of, 571
  echinococcus of, 575
  hypertrophy of, 576
    treatment of, 577
  inflammations of, specific, 574
  male, tumors of, 610
      carcinoma, 610
  neuralgia of, 576
    treatment of, 576
  syphilis of, 575
  tuberculosis of, 574
    diagnosis of, 574
    prognosis of, 574

Breast, tuberculosis of, symptoms of, 574
    treatment of, 574
  tumors of, 577
    adenoma, 580
    angioma, 580
    carcinoma, 586
      acinous, 586
      anatomical distribution of, 592
      course of, 600
      diagnosis of, 599
      etiology of, 589
      gelatinous, 588
      scirrhus, 587
      symptoms of, 596
      treatment of, 602
      tubular, 587
    chondroma of, 581
    fibro-adenoma, 578
      treatment of, 580
    lipoma, 581
    myxoma, 580
    osteoma, 581
    sarcoma, 581
      diagnosis of, 584
      treatment of, 584
    sebaceous cysts, 581
Bronchiectasis, 515
  diagnosis of, 517
  symptoms of, 516
  treatment of, 517
v. Bruns' flexible canula, 260
Burns of air-passages, 162
    diagnosis of, 163
    treatment of, 163
  of chest, 372
  of larynx, 162
    diagnosis of, 163
    treatment of, 163

CAPUT obstipum, 26
Carbuncles of chest-wall, 452
    treatment of, 452
  of neck, 75
Carcinoma of chest-wall, 471
  of larynx, 236
    diagnosis of, 239
    prognosis of, 240
    symptoms of, 238
    treatment of, 240
  of lung, 525
    diagnosis of, 525
    prognosis of, 526
    symptoms of, 525
  of male breast, 610
  of mammary gland, 585
      acinous, 586
      anatomical distribution of, 592
      course of, 600
      diagnosis of, 599
      etiology of, 589
      gelatinous, 588
      scirrhus, 587
      symptoms of, 596
Carcinoma of mammary glands, treatment of, 602
      tubular, 587
  primary, of neck, 138
      diagnosis of, 139
      prognosis of, 140
      symptoms of, 139
      treatment of, 140
  of thyroid gland, 547
Carotid arteries, arterial aneurism of, 66–70
    arteriovenous aneurism of, 73, 75
    injuries of, 44
    ligation of, 44, 49
      common, 44
        at level of cricoid cartilage, 44
        between heads of sternomastoid, 44
      external, 49
Cellulitis, diffuse, of neck, 85
Cervical rib, 24
    diagnosis of, 26
    prognosis of, 26
    symptoms of, 25
    treatment of, 26
      operation for, 26
  sympathetic nerve, injuries of, 64
Chassaignac's method of ligation of vertebral artery, 52
Chest, burns of, 372
  concussion of, 371
    diagnosis of, 372
    etiology of, 371
    prognosis of, 372
    symptoms of, 372
    treatment of, 372
  contusions of, 367
    diagnosis of, 367
    etiology of, 367
    prognosis of, 370
    treatment of, 370
  injuries of, non-perforating, 372
      burns, 372
      gunshot-wounds, 373
      prognosis of, 376
      stab- and incised wounds, 373
      treatment of, 375
  malformations of, acquired, 451
Chest-wall, abscesses of, 454
    acute, 454
    cold, 454
      treatment of, 454
    empyema necessitatis, 454
    perforating, of lung, 454
    peripleuritis, 454
  boils of, 452
      treatment of, 452
  carbuncles of, 452
      treatment of, 452
  diseases of, 452
  echinococcus of, 471
    diagnosis of, 471
    treatment of, 472

- Chest-wall, tumors of, benign, 461
  - cavernous hæmangioma, 465
    - treatment of, 465
  - dermoids, 461
    - treatment of, 461
  - enchondroma, 466
    - etiology of. 467
    - prognosis of, 468
    - symptoms of, 468
    - treatment of, 469
  - ephelides, 461
    - treatment of, 461
  - fibroma, 464
    - treatment of, 465
  - keloids, 461
    - treatment of, 461
  - lipoma, 462
    - diagnosis of, 462
    - symptoms of, 462
    - treatment of, 462
  - lymphangiomata, 465
    - treatment of, 466
  - nævi, 461
    - treatment of, 461
  - neuromata, 465
  - sebaceous cysts, 461
    - treatment of, 461
  - telangiectases, 465
  - malignant, 469
    - carcinoma, 471
    - sarcoma, 469
  - wounds of, simple penetrating, 378
- Cholesteatomata of mammary gland, 581
- Chondroma of mammary gland, 581
- Chylothorax, 487
  - diagnosis of, 487
  - prognosis of, 488
- Colloid goitre, 316
- Concussion of chest, 371
  - diagnosis of, 372
  - etiology of, 371
  - prognosis of, 372
  - symptoms of, 372
  - treatment of, 372
  - of larynx, 149
    - treatment of, 149
- Contusions of chest, 367
  - diagnosis of, 367
  - etiology of, 367
  - prognosis of, 370
  - treatment of, 370
  - fractures, 672
  - of larynx, 149
    - prognosis of, 149
    - treatment of, 149
  - of vertebræ, 672
    - etiology of, 674
    - symptoms of, 675
    - treatment of, 678
- Cord, membranes of, diseases of, 625
  - injuries of, 625
  - spinal, compression caries of, 632
    - by tumors, 633
- Cord, spinal, compression caries of, extradural, 635
  - intradural, 635
    - diagnosis of, 636
    - symptoms of, 635
  - intramedullary, 635
  - intravertebral, 635
  - pachymeningitis hypertrophica, 638
  - vertebral, 633
    - symptoms of, 633
  - destruction of, complete, 628
    - partial, 628
  - diseases of, preliminary remarks, 611
    - treatment of, 638
      - laminectomy, 641
      - neuralgia, 646
  - hæmatomyelia, 630
    - symptoms of, 630
  - injuries of, treatment of, 638
    - laminectomy, 641
    - neuralgia, 646
- Costal cartilages, dislocation of, 444
  - fracture of, 441
    - diagnosis of, 443
    - prognosis of, 444
    - symptoms of, 443
    - treatment of, 444
- Cretinism, 351
  - disturbance of, growth in, 352
  - idiocy of, 353
  - sporadic, 355
  - symptoms of, 352
  - treatment of, 354
- Cretins, thyroid gland of, 354
- Cricoid cartilage, ligation of common carotid at level of, 44
- Croupous diphtheria, 175
  - diagnosis of, 181
  - pathological anatomy of, 175
  - symptoms of, 178
  - treatment of, 181
- Curvatures of spine, 767
  - kyphosis, 769
    - prognosis of, 770
    - symptoms of, 770
    - treatment of, 770
  - lateral, 775
    - scoliosis, 775
      - congenital, 776
      - etiology of, 776
      - neuromuscular, 799
        - treatment of, 801
      - postural, 788
      - prognosis of, 789
      - rhachitic, 777
      - static, 777
      - symptoms of, 786
      - treatment of, 789
  - lordosis, 773
    - diagnosis of, 774
    - prognosis of, 774

Curvatures of spine, lordosis, treatment of, 774
Cystadenoma of breast, 571
Cystic bursæ of thyroid region, 128
        diagnosis of, 129
        symptoms of, 129
        treatment of, 129
  disease of breast, 571
  goitre, 318
    treatment of, 342
  tumor of neck, 120
Cystosarcoma phyllodes, 578
  proliferation of mammary gland, 578
Cysts, blood-, of neck, 126
      diagnosis of, 127
      symptoms of, 127
      prognosis of, 128
      treatment of, 128
  branchiogenic, of neck, 120
      diagnosis of, 122
      prognosis of, 122
      symptoms of, 122
      treatment of, 122
  congenital serous, of neck, 123
        diagnosis of, 125
        prognosis of, 125
        treatment of, 125
  echinococcus, of neck, 129
      diagnosis of, 129
      prognosis of, 130
      symptoms of, 129
      treatment of, 130
  sebaceous, of chest-wall, 461
      treatment of, 461
    of mammary gland, 581
    of neck, 128
    of skin of neck, 128
  subcutaneous dermoid, of neck, 126
        diagnosis of, 126
        treatment of, 126

DECORTIZATION of lung in pleural effusion, 499
Dermatogenic contractures, 37
Dermoid cysts, subcutaneous, of neck, 126
        diagnosis of, 126
        treatment of, 126
Dermoids of chest-wall, 461
    treatment of, 461
  of lung, 529
Diaphragm, injuries of, 418
    diagnosis of, 420
    prognosis of, 420
    symptoms of, 419
    treatment of, 421
  surgical diseases of, 555
Diphtheria, croupous, 175
    diagnosis of, 181
    pathological anatomy of, 175
    symptoms of, 178
    treatment of, 181
Dislocations, isolated, of lateral joints of vertebræ, 666
        diagnosis of, 668
        etiology of, 667
        symptoms of, 668
        treatment of, 670
  of laryngeal cartilages, 149
  of ribs, 444
    of costal cartilages, 444
    diagnosis of, 444
    prognosis of, 444
    symptoms of, 444
    treatment of, 444
    of vertebral ends of, 445
  unilateral, of lateral joints of vertebræ, 667
Ductus thyroglossus, fistulæ of, 21
      diagnosis of, 22
      prognosis of, 22
      treatment of, 22
Dupuis canula, 281

ECHINOCOCCUS of chest-wall, 471
      diagnosis of, 471
      treatment of, 472
  cysts of neck, 129
      diagnosis of, 129
      prognosis of, 130
      symptoms of, 129
      treatment of, 130
  of lung, 521
    diagnosis of, 522
    prognosis of, 522
    symptoms of, 521
  of mammary gland, 575
  of pleura, 500
    diagnosis of, 501
    symptoms of, 500
    treatment of, 501
  of spine, 761
    diagnosis of, 764
    prognosis of, 766
    symptoms of, 763
    treatment of, 767
  of thyroid gland, 346
Emphysema of mediastinum, 540
Empyema, 480
  necessitatis of chest-wall, 454
  operations for, pneumothorax after, 493
  prognosis of, 581
  symptoms of, 481
  treatment of, 481
  varieties of, 483
    metapneumonic, 483
      prognosis of, 484
      treatment of, 484
    putrid, 484
    staphylococcic, 484
    streptococcic, 484
    tuberculous, 485
      treatment of, 485
Enchondroma of chest-wall, 466

- **Enchondroma of chest-wall, etiology of, 467**
    - **prognosis of, 468**
    - **symptoms of, 468**
    - **treatment of, 469**
  - **of lung, 528**
  - **of neck, 137**
- **Endothelioma of lung, 529**
- **Enucleation in treatment of goitre, 329**
- **Ephelides of chest-wall, 461**
  - **treatment of, 461**
- **Erysipelas of neck, 76**
- **Exothyropexy in treatment of goitre, 339**
- **Exploratory puncture in operations for pleural effusions, 488**

- **FIBRO-adenoma of mammary gland, 578**
    - **treatment of, 580**
- **Fibroma of chest-wall, 464**
    - **treatment of, 465**
  - **of lung, 528**
  - **of neck, 132**
    - **diagnosis of, 132**
    - **prognosis of, 133**
    - **treatment of, 133**
- **Fistulæ of larynx, 220**
    - **diagnosis of, 221**
    - **treatment of, 222**
  - **of ductus thyroglossus, 21**
    - **diagnosis of, 22**
    - **prognosis of, 22**
    - **treatment of, 22**
  - **of neck, 17**
  - **from second branchial cleft, 18**
    - **symptoms of, 20**
    - **diagnosis of, 20**
  - **of trachea, 220**
    - **diagnosis of, 221**
    - **treatment of, 222**
- **Follicular goitre, 315**
- **Foreign bodies in air-passages, 163**
    - **diagnosis of, 169**
    - **pathological changes from, 165**
    - **prognosis of, 169**
    - **treatment of, 171**
- **Fossa, supraclavicular, abscesses of, 84**
- **Fracture of hyoid bone, 38**
    - **diagnosis of, 38**
    - **symptoms of, 38**
    - **treatment of, 38**
  - **isolated, of arches of vertebræ, 683**
    - **diagnosis of, 683**
    - **treatment of, 683**
    - **of spinous processes of vertebræ, 683**
      - **diagnosis of, 683**
      - **treatment of, 683**
    - **of transverse processes of vertebræ, 683**
      - **diagnosis of, 683**
      - **treatment of, 683**
- **Fracture, isolated, of vertebræ, 672**
    - **etiology of, 674**
    - **symptoms of, 675**
    - **treatment of, 678**
  - **of larynx, 150**
    - **anatomy of, 151**
    - **diagnosis of, 153**
    - **prognosis of, 154**
    - **symptoms of, 152**
    - **treatment of, 155**
  - **of ribs, 428**
    - **of bony portion of, 428**
      - **course of, 439**
      - **diagnosis of, 439**
      - **direct fractures, 432**
      - **indirect fractures, 432**
      - **prognosis of, 440**
      - **symptoms of, 437**
      - **treatment of, 440**
    - **of costal cartilages, 441**
      - **diagnosis of, 443**
      - **prognosis of, 444**
      - **symptoms of, 443**
      - **treatment of, 444**
  - **of sternum, 421**
    - **course of, 426**
    - **diagnosis of, 426**
    - **prognosis of, 427**
    - **symptoms of, 425**
    - **treatment of, 427**
  - **of trachea, 155**
    - **diagnosis of, 156**
    - **prognosis of, 156**
    - **symptoms of, 156**
    - **treatment of, 157**
  - **of vertebræ due to compression, r**
    sults of, 681
- **Franz's method of ligation of vertebr**
  artery, 52
- **Funnel chest, 448**

- **GANGRENE of lung, 510**
    - **diagnosis of, 513**
    - **symptoms of, 512**
    - **treatment of, 513**
- **Gelatinous carcinoma of mammar**
  gland, 588
- **Glisson's sling, 731**
- **Gluck's phonation apparatus, 291**
- **Goitre, 297**
  - **abnormal position of, 310**
  - **accessory, 310**
  - **colloid, 316**
  - **cystic, 318**
    - **treatment of, 342**
  - **diagnosis of, 313**
  - **diffuse hypertrophy, 300**
  - **endolaryngeal, 313**
  - **etiology of, 297**
  - **follicular, 315**
  - **inflammations of, 344**
  - **injuries of, 344**
  - **partial hypertrophy, 300**

- Goitre, pathological anatomy of, 299
  - post-operative tetany, 334
  - recurrence of, after operation, 330
  - relations of, to surrounding tissues, 304
  - symptoms of, 307
  - treatment of, 320
    - medicinal, 320
      - injection-therapy, 321
      - organotherapy, 321
    - surgical, 322
      - dangers of, 331
      - enucleation, 329
      - exothyropexy, 339
      - ligation of thyroid artery, 339
      - partial excision, 325
      - tracheotomy, 341
      - transplantation of goitre, 339
  - varieties of, 303
- Graves' disease, 357
  - diagnosis of, 358
  - etiology of, 357
  - prognosis of, 358
  - symptoms of, 357
  - treatment of, 359

- HÆMANGIOMA, cavernous, of chest-wall, 465
    - treatment of, 465
  - of neck, 130
- Hæmatomyelia, 630
  - symptoms of, 630
- Hæmothorax, 486
  - symptoms of, 486
  - treatment of, 487
- Heart, injuries of, 403
    - diagnosis of, 409
    - prognosis of, 410
    - symptoms of, 406
    - treatment of, 412
  - operations on, 553
  - surgical diseases of, 548
- Helferich's method of ligation of vertebral artery, 53
- Hemorrhage into mediastinum, 540
- Hernia of lung, 455
- Hessing's corset, 741
- Hydrothorax, 486
  - treatment of, 486
- Hyoid bone, diseases of, 38
    - fracture of, 38
      - diagnosis of, 38
      - symptoms of, 38
      - treatment of, 38
    - inflammations of, 39
    - tumors of, 39
- Hyperplasia of thymus, 363
- Hyperplastic lymphoma, simple, 89
    - diagnosis of, 92
    - prognosis of, 92
    - treatment of, 92
- Hypertrophy, diffuse, of thyroid gland, 300
- Hypertrophy, of mammary gland, 576
    - treatment of, 577
  - partial, of thyroid gland, 300

- IDIOCY of cretins, 353
- Inflammations of goitre, 344
  - of hyoid bone, 39
  - of normal thyroid gland, 344
  - infective, of thyroid gland, 345
  - of neck, 75
    - complications of, 85
  - specific, of breast, 574
    - of larynx, 204
  - of trachea, 204
  - submental, 83
  - surrounding great vessels, 83
      - prognosis of, 84
      - treatment of, 84
  - of thorax, 453
    - diagnosis of, 453
    - treatment of, 453
  - of vascular space, 83
      - prognosis of, 84
      - treatment of, 84
- Inflammatory diseases of larynx, 175
    - of trachea, 175
  - processes of mediastinum, 530
- Injection-therapy in treatment of goitre, 321
- Innominate artery, arterial aneurisms of, 70
      - diagnosis of, 71
      - treatment of, 71
    - ligation of, 54
      - technic of, 54
  - vein, ligation of, 61
- Intercostal neuralgia, 460
    - treatment of, 460
- Intrathoracic vessels, large, injuries of, 417
- Intubation of larynx, 184
    - apparatus and technic of, 184
- Ischias scoliatica, 799

- JAW, angle of, abscess at, 83
- Jugular veins, internal, arterio-venous aneurisms of, 73, 75
      - ligation of, 59, 60
        - external, 60
        - internal, 59
- Jury mast, 737

- KELOIDS of chest-wall, 461
    - treatment of, 461
- Kocher's method of ligation of vertebral artery, 52
- König's spiral canula, 260
- Kyphosis, 769
  - prognosis of, 770
  - symptoms of, 770
  - treatment of, 770

LAMINECTOMY, bone forceps for, 642
  with opened dura, 643
Laryngeal cartilages, dislocation of, 149
Laryngitis hypoglottica, 197, 199
  submucosa, 195
    diagnosis of, 198
    prognosis of, 198
    symptoms of, 197
    treatment of, 198
Laryngocele, 147
  diagnosis of 148
  etiology of, 147
  symptoms of, 148
  treatment of, 148
Laryngotomy 276
  complications of, 287
  indications for, 276
  laryngotracheotomy, 277
  longitudinal section in, 276
  partial, 277
  suprathyroidea, 277
  technic of, 277
  total, 276
  transverse division in, 277
Laryngotracheotomy, 277
Larynx, actinomycosis of, 209
    treatment of, 210
  angioma of, 227
  artificial, 288
  burns of, 162
    diagnosis of, 163
    treatment of, 163
  carcinoma of, 236
    diagnosis of, 239
    prognosis of, 240
    symptoms of, 238
    treatment of, 240
  concussion of, 149
    treatment of, 149
  contusions of, 149
    prognosis of, 149
    treatment of, 149
  excision of, 282
    technic of, 282
  fibromata of, 225
  fistulæ of, 220
    diagnosis of, 221
    treatment of, 222
  fracture of, 150
    anatomy of, 151
    diagnosis of, 153
    prognosis of, 154
    symptoms of, 152
    treatment of, 155
  inflammations of, specific, 204
  inflammatory diseases of, 175
  intubation of, 184
    apparatus and technic of, 104
  leprosy of, 211
    diagnosis of, 211
    prognosis of, 211
    treatment of, 211
Larynx, lipoma of, 227
  lupus of, 207
    diagnosis of, 207
    prognosis of, 207
    treatment of, 207
  malformations of, 145
    treatment of, 146
  myxomata of, 227
  neuroses of, 223
    treatment of, 224
  new growths of, 225
  œdema of, 195
    symptoms of, 197
    diagnosis of, 198
    prognosis of, 198
    treatment of, 198
  papillomata of, 226
  sarcoma of, 233
    diagnosis of, 234
    treatment of, 235
  scleroma of, 210
    diagnosis of, 210
    prognosis of, 210
    treatment of, 210
  stenosis of, 211
    diagnosis of, 213
    prognosis of, 213
    treatment of, 213
  syphilis of, 207
    treatment of, 209
  tuberculosis of, 204
    diagnosis of, 205
    prognosis of, 205
    treatment of, 206
  tumors of, benign, 225
      diagnosis of, 228
      prognosis of, 228
      symptoms of, 228
      treatment of, 229
    malignant, 233
  wounds of, 157
    gunshot-, 157
      prognosis of, 158
      symptoms of, 158
    incised and stab-, 158
        diagnosis of, 159
        prognosis of, 159
        symptoms of 159
        treatment of, 160
Leprosy of larynx, 211
    diagnosis of, 211
    prognosis of, 211
    treatment of, 211
Lingual artery, ligation of, 50
      technic of, 51
Lipoma of chest-wall, 462
    diagnosis of, 462
    symptoms of, 462
    treatment of, 462
  of lung, 528
  of mammary gland, 581
  of neck, 133
    diagnosis of, 136

- Lipoma of neck, etiology of, 136
  - treatment of, 136
- Lordosis, 773
  - diagnosis of, 77
  - prognosis of, 774
  - treatment of, 774
- Luer's double canula, 258
- Lungs, abscess of, 506
    - diagnosis of, 507
    - perforating, 454
    - prognosis of, 508
    - symptoms of, 507
    - treatment of, 508
  - actinomycosis of, 522
    - diagnosis of, 524
    - symptoms of, 523
  - diseases of, 502
    - general technic of operations for, 502
  - echinococcus of, 521
    - diagnosis of, 522
    - prognosis of, 522
    - symptoms of, 521
  - gangrene of, 510
    - diagnosis of, 513
    - symptoms of, 512
    - treatment of, 513
  - hernia of, 455
  - injuries of, 383
    - diagnosis of, 391
    - prognosis of, 392
    - symptoms of, 384
    - treatment of, 393
  - tuberculosis of, 519
  - tumors of, benign, 528
      - dermoids, 529
      - enchondromata, 528
      - endotheliomata, 529
      - fibromata, 528
      - lipomata, 528
      - miliary lymphomata, 528
      - osteomata, 529
    - malignant, 525
      - carcinoma, 525
        - diagnosis of, 525
        - prognosis of, 526
        - symptoms of, 525
      - sarcoma, 526
        - diagnosis of, 527
        - treatment of, 527
- Lupus of larynx, 207
  - diagnosis of, 207
  - prognosis of, 207
  - treatment of, 207
- Lymphadenitis, acute, 89
  - chronic, 89
- Lymphangioma cavernosum of neck, 131
    - diagnosis of, 131
    - treatment of, 131
  - of chest-wall, 465
    - treatment of, 466
- Lymph-glands of neck, diseases of, 89
- Lymph-glands of neck, neoplasms of, 109
  - secondary malignant involvement of, 119
  - syphilis of, 108
- Lymphoma, malignant, 110
    - anatomical relations of, 112
    - diagnosis of, 114
    - prognosis of, 115
    - treatment of, 115
    - types of, 110
  - miliary, of lung, 528
  - scrofulous, 93
  - simple, 89
    - diagnosis of, 92
    - hyperplastic, 89
    - prognosis of, 92
    - treatment of, 92
  - tuberculous, 94
    - diagnosis of, 101
    - etiology of, 95
    - hyperplasia with tubercles, 94
    - hyperplastic type, 94
    - prognosis of, 102
    - secondary conditions due to extension of inflammation, 94
    - symptoms of, 98
      - lymphoma associated with periglandular processes, 100
        - without periadenitis, 98
    - treatment of, 103
- Lymphosarcoma of neck, 109, 118
    - symptoms of, 119
    - treatment of, 119

- MALUM suboccipitale, 726
- Mammary gland, actinomycosis of, 575
  - anatomical remarks, 557
  - anatomy of, 555
  - congenital malformations of, 562
  - diseases of, 564
  - echinococcus of, 575
  - hypertrophy of, 576
    - treatment of, 577
  - inflammation of, 565
  - injuries of, 563
  - neuralgia of, 576
    - treatment of, 576
  - physiological remarks, 557
  - physiology of, 557
  - syphilis of, 575
  - tuberculosis of, 574
    - diagnosis of, 574
    - prognosis of, 574
    - symptoms of, 574
    - treatment of, 574
  - tumors of, 577
    - adenoma, 580
    - angioma, 580
    - carcinoma, 585
      - acinous, 586

- Mammary gland, tumors of, carcinoma, anatomical distribution of, 592
      - course of, 600
      - diagnosis of, 599
      - etiology of, 589
      - gelatinous, 588
      - pathological differences, 586
      - scirrhus, 587
      - symptoms of, 596
      - treatment of, 602
      - tubular, 587
    - chondroma, 581
    - fibro-adenoma, 578
      - treatment of, 580
    - lipoma, 581
    - myxoma, 580
    - osteoma, 581
    - sarcoma, 581
      - diagnosis of, 584
      - treatment of, 584
    - sebaceous cysts, 581
- Mastitis, 565
  - chronic cystic, 571
  - infective, 568
    - treatment of, 568
  - puerperalis, 567
    - etiology of, 567
  - simple, 568
    - treatment of, 568
- Mastodynia, 576
  - treatment of, 576
- Mediastinitis, acute, 530
    - diagnosis of, 532
    - prognosis of, 533
    - symptoms of, 530
    - treatment of, 533
  - chronic, 530
    - diagnosis of, 532
    - prognosis of, 533
    - symptoms of, 530
    - treatment of, 533
- Mediastinum, diseases of, 530
  - emphysema of, 540
  - hemorrhage into, 540
  - syphilis of, 540
  - tumors of, benign, 537
    - malignant, 539
    - primary, 536
      - course of, 537
      - diagnosis of, 537
      - etiology of, 536
      - symptoms of, 536
    - secondary, 539
      - prognosis of, 539
      - symptoms of, 539
      - treatment of, 539
- Membranes of cord, diseases and injuries of, 625
- Metapneumonic empyema, 483
    - prognosis of, 484
    - treatment of, 484
- Mikulicz's method of ligation of ver bral artery, 52
- Muscular wry-neck, 26
    - anatomy of, 29
    - diagnosis of, 32
    - etiology of, 27
    - prognosis of, 32
    - symptoms of, 31
    - treatment of, 32
- Myelocystocele, 655
- Myelo-cysto-meningocele, 661
- Myelomeningocele, 653
- Myogenic contractures, 37
- Myxœdema, 355
  - diagnosis of, 356
  - infantile, 355
  - symptoms of, 355
    - due to removal or complete destr tion of thyroid gland, 357
  - treatment of, 356
- Myxoma intracanaliculare, 578
  - of mammary gland, 580

- NÆVI of chest-wall, 461
  - treatment of, 461
- Neck, abscesses of, 76
    - branchiogenic, 123
  - actinomycosis of, 86
    - diagnosis of, 87
    - prognosis of, 87
    - treatment of, 88
  - aneurism of, 66
    - arterial, 66
      - of common carotid, 66
          - of beginning of, 70
          - prognosis of, 68
          - treatment of, 68
          - of upper part of, 68
      - of external carotid, 70
      - of innominate, 70
        - diagnosis of, 71
        - treatment of, 71
      - of internal carotid, 70
      - of subclavian above collar bon 72
          - prognosis of, 72
          - treatment of, 72
    - arteriovenous, 73
      - of common carotid and intern jugular, 73
          - prognosis of, 74
          - symptoms of, 73
          - treatment of, 74
      - of external carotid and i ternal jugular, 75
      - extracranial, of internal caroti 75
      - of subclavian vessels, 75
  - angioma of, cavernous, 130
    - prognosis of, 131
    - symptoms of, 131
    - treatment of, 131
    - simplex, 130

- Neck, arteries of, injuries of, 40
    - diagnosis of, 41
    - prognosis of, 42
    - symptoms of, 40
    - treatment of, 42
  - ligation of, 44–55
    - common carotid, 44
      - at level of cricoid cartilage, 44
      - between heads of sternomastoid, 44
    - external carotid, 49
    - innominate, 54
      - technic of, 54
    - lingual, 50
      - technic of, 51
    - subclavian, in supraclavicular fossa, 53
      - technic of, 54
    - vertebral, 51
      - Chassaignac's method, 52
      - Fray's and Kocher's method, 52
      - Helferich's method, 53
      - Mikulicz's method, 52
  - boils of, 75
  - branchial clefts, outgrowths of skin of, 23
  - carbuncles of, 75
  - carcinoma of, primary, 138
    - diagnosis of, 139
    - prognosis of, 140
    - symptoms of, 139
    - treatment of, 140
  - cysts, blood-, of, 126
      - diagnosis of, 127
      - symptoms of, 127
      - prognosis of, 128
      - treatment of, 128
    - branchiogenic, 120
      - diagnosis of, 122
      - prognosis of, 122
      - symptoms of, 122
      - treatment of, 122
    - congenital serous, 123
      - diagnosis of, 125
      - prognosis of, 125
      - treatment of, 125
    - subcutaneous dermoid, 126
      - diagnosis of, 126
      - treatment of, 126
  - enchondroma of, 137
  - erysipelas of, 76
  - fibroma of, 132
    - diagnosis of, 132
    - prognosis of, 133
    - treatment of, 133
  - fistula of, 17
    - of ductus thyroglossus, 21
      - diagnosis of, 22
      - prognosis of, 22
      - treatment of, 22
    - from second branchial cleft, 18
- Neck, fistula of, from second branchial cleft, diagnosis of, 20
      - symptoms of, 20
  - hæmangioma of, 130
  - inflammations of, 75
    - complications of, 85
  - lipoma of, 133
    - diagnosis of, 136
    - etiology of, 136
    - treatment of, 136
  - lymphangioma cavernosum of, 131
      - diagnosis of, 131
      - treatment of, 131
  - lymph-glands of, diseases of, 89
    - neoplasms of, 109
    - secondary malignant involvement of, 119
    - syphilis of, 108
  - lymphosarcoma of, 118
    - primary, 109
    - symptoms of, 119
    - treatment of, 119
  - nerves of, injuries of, 62
      - brachial plexus, 64
      - cervical sympathetic, 64
      - spinal accessory, 65
      - vagus, 62
  - neuroma of, 136
  - osteoma of, 137
  - sarcoma of, primary, 137
  - skin of, sebaceous cysts of, 128
  - suppuration of, 76
    - submaxillary, 81
      - diagnosis of, 82
      - prognosis of, 83
      - treatment of, 83
    - symptoms of, 81
  - teratoma of, 24
    - diagnosis of, 24
    - symptoms of, 24
    - treatment of, 24
  - tuberculous abscesses of, 85
  - tumors of, branchiogenic, 123
    - cystic, 120
    - solid, 132
    - vascular, 130
  - veins of, injuries of, 55
    - ligation of, 59–61
      - innominate, 61
      - jugular, external, 60
        - internal, 59
      - subclavian, 60
- Neoplasms of lymph-glands of neck, 109
- Nerves of neck, injuries of, 62
    - brachial plexus, 64
    - cervical sympathetic, 64
    - spinal accessory, 65
    - vagus, 62
- Neuralgia, intercostal, 460
  - treatment of, 460
  - of mammary gland, 576
    - treatment of, 576

Neurogenic contractions, 37
Neuroma of neck, 136
Neuromata of chest-wall, 465
Neuromuscular scoliosis, 799
    treatment of, 801
Neuroses of larynx, 223
    treatment of, 224
Nipple, diseases of, 564

O'DWYER'S apparatus for intubation of larynx, 186
Œdema of larynx, 185
    diagnosis of, 198
    prognosis of, 190
    symptoms of, 197
    treatment of, 198
Organotherapy in treatment of goitre, 321
Osteoma of lung, 529
  of mammary gland, 581
  of neck, 137
Osteomyelitis, acute, of vertebræ, 697
      diagnosis of, 699
      prognosis of, 699
      treatment of, 700
  of ribs, 455
  of sternum, 455

PARACENTESIS in operations for pleural effusions, 488
Pericardial effusions, operations upon, 548
      indications for, 548
      operative technic, 549
        incision into pericardium, 551
        puncture of pericardium, 549
Pericarditis, purulent, 548
Pericardium, incision into, 551
  injuries of, 399
    diagnosis of, 400
    prognosis of, 401
    symptoms of, 399
    treatment of, 401
  puncture of, 549
  surgical diseases of, 548
Perichondritis laryngea, 200
    diagnosis of, 203
    etiology of, 200
    prognosis of, 203
    symptoms of, 203
    treatment of, 203
Peripleuritic abscesses, 454
Pleura, echinococcus of, 500
    diagnosis of, 501
    symptoms of, 500
    treatment of, 501
  effusions of, 473
    mechanical results of, 473
    operations for, 488
      exploratory puncture, 488
      paracentesis, 488
        with suction drainage, 489
Pleura, effusions of, operations for, thoracotomy, 490
        with resection of ribs, 490
  isolated injuries of, 378
      diagnosis of, 382
      prognosis of, 382
      symptoms of, 381
      treatment of, 382
  tumors of, malignant, 500
      diagnosis of, 500
      treatment of, 500
Pleuritis exudativa serosa, 478
      etiology of, 478
      symptoms of, 479
      treatment of, 479
Pneumothorax after operations for empyema, 493
Postural scoliosis, 778
Pott's disease. *See* Spondylitis tuberculosa.
Pseudocroup, 199
  diagnosis of, 199
  symptoms of, 199
  treatment of, 200
Puerperal mastitis, 567
    etiology of, 567
Putrid empyema, 484
Pyothorax, 480
  prognosis of, 481
  symptoms of, 481
  treatment of, 481

RHACHISCHISIS, 661
Rhachitic scoliosis, 777
Ribs, cervical, 24
    diagnosis of, 25
    prognosis of, 26
    symptoms of, 25
    treatment of, 26
      operations for, 26
  congenital malformations of, 449
  dislocation of, 444
    of costal cartilages of, 444
    diagnosis of, 445
    prognosis of, 444
    symptoms of, 444
    treatment of, 444
    of vertebral ends, 445
  fractures of, 428
    of bony portion of, 428
      course of, 439
      diagnosis of, 439
      direct fractures, 432
      indirect fractures, 432
      prognosis of, 440
      symptoms of, 437
      treatment of, 440
    of costal cartilages of, 441
      diagnosis of, 443
      prognosis of, 444
      symptoms of, 443
      treatment of, 444
  osteomyelitis of, 455

Ribs, syphilis of, 458
    diagnosis of, 458
    treatment of, 458
  tuberculosis of, 456
    diagnosis of, 457
    prognosis of, 457
    treatment of, 457
  vertebral ends of, dislocation of, 448

SARCOMA of chest-wall, 469
  of larynx, 233
    diagnosis of, 234
    treatment of, 235
  of lung, 526
    diagnosis of, 527
    treatment of, 527
  of mammary gland, 581
    diagnosis of, 584
    treatment of, 584
  primary, of neck, 137
  of thyroid gland, 347
Schede's operation for pleural effusion, 494
Schrötter's plug for stenosis of larynx, 215
Scirrhous carcinoma of mammary gland, 587
Scleroma of larynx, 210
    diagnosis of, 210
    prognosis of, 210
    treatment of, 210
Scoliosis, 775
  congenital, 776
  etiology of, 776
  neuromuscular, 799
    treatment of, 801
  postural, 778
  prognosis of, 789
  rhachitic, 777
  static, 777
  symptoms of, 786
  treatment of, 789
Scoliosometer, 788
Scrofulous lymphoma, 93
Sebaceous cysts of skin of neck, 128
Serothorax, 478
  etiology of, 478
  symptoms of, 479
  treatment of, 479
Serous cysts, congenital, of neck, 123
      diagnosis of, 125
      prognosis of, 125
      treatment of, 125
Simon-Küster's operation for effusion of pleura, 494
Spina bifida, 652
    diagnosis of, 656
    prognosis of, 657
    treatment of, 658
Spinal accessory nerve, injuries of, 65
  cord, compression of, in caries of vertebræ, 632
      by tumors, 633
Spinal cord, destruction of, complete, 628
      partial, 628
    hæmatomyelia, 630
      symptoms of, 630
    stab-wounds of, 629
      prognosis of, 630
      symptoms of, 629
      treatment of, 630
    treatment of injuries and diseases of, 638
Spine, actinomycosis of, 755
    diagnosis of, 756
    prognosis of, 756
    symptoms of, 756
    treatment of, 757
  curvatures of, 767
    ankylosis, 772
    kyphosis, 769
      prognosis of, 770
      rhachitic, 773
        diagnosis of, 773
        prognosis of, 773
        treatment of, 773
      symptoms of, 770
      treatment of, 770
    lateral, 775
      scoliosis, 775
        congenital, 775
        etiology of, 776
        neuromuscular, 799
        postural, 778
        symptoms of, 786
        rhachitic, 777
        static, 777
        treatment of, 789
        prognosis of, 789
    lordosis, 773
      diagnosis of, 774
      prognosis of, 774
      treatment of, 774
    sagittal anomalies of posture, 769
  diseases of, 797
  echinococcus cyst of, 761
      diagnosis of, 764
      prognosis of, 766
      symptoms of, 763
      treatment of, 767
  exostosis of, 767
  gunshot-wound of, 694
    symptoms of, 695
    treatment of, 695
  myelomata of, 765
  spondylarthritis of, 725
    cold abscesses, 745
        treatment of, 745
          camphor-napthol, 747
          iodoform and formalin, 747
          iodoform-glycerin, 745
        results of, 750
    diagnosis of, 729
    paralysis, 751
      treatment of, 752
    prognosis of, 729

Spine, spondylarthritis of, symptoms of, 728
    treatment of, 730
      baths in, 731
      Calot's method, 743
      celluloid corsets, 739
      extension, 732
      felt corsets, 740
      Hessing's corsets, 741
      iodine injections, 731
      leather corsets, 739
      Lorenz's plaster-of-Paris casts, 733
      Nebel's apparatus, 733
      plaster-of-Paris corsets, 739
      Rauchfuss' swing, 733
      Sayre's method, 737
      Schaffer's method, 744
      traction, 732
    tuberculosis, 745
      iodoform treatment, 745
  stab-wounds of 694
    symptoms of, 695
    treatment of, 695
  syphilis of, 753
    treatment of, 755
  tuberculosis of, 701
    diagnosis of, 723
    pathological anatomy of, 703
    prognosis of, 724
    symptoms of, 714
  tumors of, 761
    diagnosis of, 764
    prognosis of, 766
    symptoms of, 763
      bone, 765
      root, 766
    treatment of, 767
Spinous processes of vertebræ, isolated fractures of, 683
      diagnosis of, 683
      treatment of, 683
Spondylarthritis, 725
  diagnosis of, 729
  etiology of, 725
  prognosis of, 729
  symptoms of, 728
  treatment of, 730
Spondylitis deformans, 757
    diagnosis of, 760
    etiology of, 757
    prognosis of, 761
    symptoms of, 759
    treatment of, 761
  traumatic, 679
    diagnosis of, 680
    prognosis of, 680
    symptoms of, 679
    treatment of, 681
  tuberculosa, 701
    pathological anatomy of, 703
    symptoms of, 714
    diagnosis of, 723
Spondylitis tuberculosa, prognosis of, 724
Sporadic cretinism, 355
Staphylococcic empyema, 484
Static scoliosis, 777
Stenosis of larynx, 211
    diagnosis of, 213
    prognosis of, 213
    treatment of, 213
  of trachea, 218
    diagnosis of, 219
    etiology of, 218
    prognosis of, 219
    symptoms of, 219
    treatment of, 219
Sternomastoid, diseases of, 26
  ligation of common carotid between heads of, 44
  syphilis of, 38
    symptoms of, 38
    treatment of, 38
Sternum, congenital fissure of, 447
    malformations of, 446
  fractures of, 421
    course of, 426
    diagnosis of, 426
    prognosis of, 427
    symptoms of, 425
    treatment of, 427
  osteomyelitis of, 455
  syphilis of, 458
    diagnosis of, 458
    treatment of, 458
  tuberculosis of, 456
    diagnosis of, 457
    prognosis of, 457
    treatment of, 457
Streptococcic empyema, 484
Subclavian artery, arterial aneurism of, 72
      prognosis of, 72
      treatment of, 72
    arteriovenous aneurisms of, 75
    injuries of, 43
      prognosis of, 43
      treatment of, 43
    ligation of, 53
      technic of, 54
  veins, ligation of, 60
Submaxillary suppuration, 81
    diagnosis of, 82
    prognosis of, 83
    treatment of, 83
Submental inflammation, 83
Suppuration of neck, 76
    symptoms of, 81
  submaxillary, 81
    diagnosis of, 82
    prognosis of, 83
    treatment of, 83
Supraclavicular fossa, abscesses of, 84
Syphilis of breast, 575
  of larynx, 207

- Syphilis of larynx, treatment of, 209
  - of lymph-glands of neck, 108
  - of mediastinum, 540
  - of ribs, 458
    - diagnosis of, 458
    - treatment of, 458
  - of spine, 753
    - treatment of, 755
  - of sternomastoid, 38
    - symptoms of, 38
    - treatment of, 38
  - of sternum, 458
    - diagnosis of, 458
    - treatment of, 458
  - of thyroid gland, 346
  - of trachea, 207
    - treatment of, 209

- TELANGIECTASES of chest-wall, 465
- Teratoma of neck, 24
  - diagnosis of, 24
  - symptoms of, 24
  - treatment of, 24
- Thoracic aorta, aneurisms of, 541
  - treatment of sac contents, 542
    - of vessel-wall, 542
  - duct, injuries of, 61, 418
    - treatment of, 62
  - muscles, congenital malformations of, 450
  - wall, actinomycosis of, 458
    - diagnosis of, 459
    - prognosis of, 460
    - symptoms of, 459
    - treatment of, 460
- Thoracotomy in operations for pleural effusions, 490
- Thorax, inflammations of, 453
  - diagnosis of, 453
  - treatment of, 453
  - injuries of, 367
  - malformations of, 446
- Thymus, diseases of, 363
  - hyperplasia of, 363
  - tumors of, 364
- Thyroid artery, ligation of, in treatment of goitre, 339
  - gland, alveolar tumors of, 351
    - diagnosis of, 351
    - prognosis of, 351
    - treatment of, 351
    - accessory, anterior, 313
      - endolaryngeal, 313
      - inferior, 311
      - posterior, 312
      - superior, 313
      - tracheal, 313
    - actinomycosis of, 346
    - anatomy of, 293
    - carcinoma of, 347
    - of cretins, 354
    - diseases of, 297
- Thyroid gland, echinococcus of, 346
  - function of, 296
  - hypertrophy of, diffuse, 300
    - partial, 300
  - inflammation of, infective, 345
  - injuries of, 344
  - lues, 346
  - metastatic growths of, 346
  - new growths of, 347
    - diagnosis of, 351
    - prognosis of, 351
    - treatment of, 351
  - normal, inflammations of, 344
  - pharmacological peculiarities of, 295
  - physiology of, 293
  - sarcoma of, 347
  - symptoms of myxœdema due to removal or complete destruction of, 357
  - syphilis of, 346
  - tuberculosis of, 345
- Thyrotomy, 277
- Torticollis. *See* Wry neck.
- Trachea, carcinoma of, 247
  - fibroma of, 246
  - fistulæ of, 220
    - diagnosis of, 221
    - treatment of, 222
  - fracture of, 155
    - diagnosis of, 156
    - prognosis of, 156
    - symptoms of, 156
    - treatment of, 156
  - inflammations of, specific, 204
  - inflammatory diseases of, 175
  - lipoma of, 247
  - malformations of, 147
  - new growths of, 246
    - diagnosis of, 249
    - symptoms of, 248
    - treatment of, 249
  - osteoma of, 247
  - packing of, 273
  - papilloma of, 246
  - sarcoma of, 247
  - stenosis of, 218
    - diagnosis of, 219
    - etiology of, 218
    - prognosis of, 219
    - symptoms of, 219
    - treatment of, 219
  - syphilis of, 207
    - treatment of, 209
  - thyroid tumors of, 247
  - tumors of, benign, 246
    - malignant, 247
  - wounds of, 157
    - gunshot-, 157
      - prognosis of, 158
      - symptoms of, 158
    - incised and stab-, 158
      - diagnosis of, 159

Trachea, wounds of, incised and stab-,
        prognosis of, 159
        symptoms of, 159
        treatment of, 159
Tracheocele, 147
  diagnosis of, 148
  etiology of, 147
  symptoms of, 148
  treatment of, 148
Tracheotomy, 250
  accidents during convalescence, 264
    during operations, 261
  anatomical remarks, 250
  granulomata following, 268
    diagnosis of, 268
    prognosis of, 268
    symptoms of, 268
    treatment of, 268
  hemorrhage during, 266
  indications for, 250
  inferior, 256
  stenosis, 270
    varieties of, 270
  superior, 256
  technic of, 253
  in treatment of goitre, 341
  tube, 259
Transverse processes of vertebræ, isolated fractures of, 683
        diagnosis of, 683
        treatment of, 683
Traumatic spondylitis, 679
    symptoms of, 679
    diagnosis of, 680
    prognosis of, 680
Trendelenburg's canula with Rosenbach's control-bulb, 274
Tuberculosis of breast, 574
    diagnosis of, 574
    prognosis of, 574
    symptoms of, 574
    treatment of, 574
  of larynx, 204
    diagnosis of, 205
    prognosis of, 205
    treatment of, 206
  of lung, 519
  of ribs, 456
    diagnosis of, 457
    prognosis of, 457
    treatment of, 457
  of spine, 701
    diagnosis of, 723
    pathological anatomy of, 703
    prognosis of, 724
    symptoms of, 714
  .of sternum, 456
    diagnosis of, 457
    prognosis of, 457
    treatment of, 457
  of thyroid gland, 345
Tuberculous abscesses of neck, 85
  empyema, 485
Tuberculous empyema, treatment of, 485
  lymphoma, 94
    diagnosis of, 101
    etiology of, 95
    prognosis of, 102
    symptoms of, 98
      without periadenitis, 98
      associated with periglandular processes, 100
    treatment of, 103
Tubular carcinoma of mammary glands, 587
Tumors, benign, of chest-wall, 461
      cavernous hæmangioma, 465
        treatment of, 465
      dermoids, 461
        treatment of, 461
      enchondroma, 466
        etiology of, 467
        prognosis of, 468
        symptoms of, 468
        treatment of, 469
      ephelides, 461
        treatment of, 461
      fibroma, 464
        treatment of, 465
      keloids, 461
        treatment of, 461
      lipoma, 462
        diagnosis of, 462
        symptoms of, 462
        treatment of, 462
      lymphangiomata, 465
        treatment of, 466
      nævi, 461
        treatment of, 461
      neuromata, 465
      sebaceous cysts, 461
          treatment of, 461
      telangiectases, 465
    of larynx, 225
      diagnosis of, 228
      prognosis of, 228
      symptoms of, 228
      treatment of, 229
    of lungs, 528
      dermoids, 529
      enchondromata, 528
      endotheliomata, 529
      fibromata, 528
      lipomata, 528
      miliary lymphomata, 528
      osteomata, 529
    of mediastinum, 537
  branchiogenic, of neck, 123
  compression of spinal cord by, 633
  cystic, of neck, 120
  of hyoid bone, 39
  of male breast, 610
  malignant, of chest-wall, 469
      carcinoma, 471
      sarcoma, 469
    of larynx, 233

- Tumors, malignant, of lung, 525
      - carcinoma, 525
        - diagnosis of, 525
        - prognosis of, 526
        - symptoms of, 525
      - sarcoma, 526
        - diagnosis of, 527
        - treatment of, 527
    - of mediastinum, 539
    - of pleura, 500
      - diagnosis of, 500
      - treatment of, 500
    - of vessel-sheaths, 137
  - of mammary gland, 577
      - adenoma, 580
      - angioma, 580
      - carcinoma, 585
        - acinous, 586
        - anatomical distribution of, 592
        - course of, 600
        - diagnosis of, 599
        - etiology of, 589
        - gelatinous, 588
        - scirrhous, 587
        - symptoms of, 596
        - treatment of, 602
        - tuberculous, 587
      - chondroma, 581
      - fibro-adenoma, 578
          - treatment of, 580
      - lipoma, 581
      - myxoma, 580
      - osteoma, 581
      - sarcoma, 581
        - diagnosis of, 584
        - treatment of, 584
      - sebaceous cysts, 581
    - of mediastinum, 536
      - course of, 537
      - diagnosis of, 537
      - etiology of, 536
      - symptoms of, 536
  - secondary, of mediastinum, 539
      - prognosis of, 539
      - symptoms of, 539
      - treatment of, 539
  - solid, of neck, 132
  - of spine, 761
    - diagnosis of, 764
    - prognosis of, 766
    - symptoms of, 763
    - treatment of, 767
  - of thymus, 364
  - vascular, of neck, 130

- VAGUS nerve, injuries of, 62
  - Vascular space, abscesses of, 83
        - prognosis of, 84
        - treatment of, 84
      - inflammation of, 83
        - prognosis of, 84
        - treatment of, 84
    - tumors of neck, 130

- Veins of neck, injuries of, 55
    - ligation of, 59–61
      - internal jugular, 59
      - external jugular, 60
      - subclavian, 60
      - innominate, 61
- Vertebræ, acute osteomyelitis of, 697
      - diagnosis of, 699
      - prognosis of, 699
      - treatment of, 700
  - arches of, fractures of, isolated, 683
        - diagnosis of, 683
        - treatment of, 683
  - caries of, compression of spinal cord in, 632
  - complete dislocation of, with fracture, 684
        - diagnosis of, 692
        - etiology of, 691
        - symptoms of, 691
        - treatment of, 693
  - contusions of, 672
    - etiology of, 674
    - symptoms of, 675
    - treatment of, 678
  - fractures of, due to compression, results of, 681
      - isolated, 672
      - etiology of, 674
      - symptoms of, 675
      - treatment of, 678
  - injuries of, 664
  - lateral joints of, distortions of, 664
      - dislocation of, isolated, 664, 666
  - lateral joints of, dislocation of, unilateral, 667
          - diagnosis of, 668
          - etiology of, 667
          - symptoms of, 668
          - treatment of, 670
  - spinous processes of, fractures of, isolated, 683
          - diagnosis of, 683
          - treatment of, 683
  - transverse processes of, fractures of, isolated, 683
          - diagnosis of, 683
          - treatment of, 683
  - vertebral articulation, distortion of, 665
        - diagnosis of, 666
        - symptoms of, 665
        - treatment of, 666
- Vertebral artery, injuries of, 43
      - diagnosis of, 43
      - prognosis of, 43
      - treatment of, 43
    - ligation of, 51
      - Chassaignac's method, 52
      - Frays and Kocher's method, 52
      - Helferich's method, 53
      - Mikulicz's method, 52
  - column, malformations of, 652

Vessel-sheaths, malignant tumors of, 137

WOUNDS of larynx, 157
  gunshot-wounds, 157
    symptoms of, 158
    prognosis of, 158
  incised and stab-wounds, 158
    diagnosis of, 159
    prognosis of, 159
    symptoms of, 159
    treatment of, 160
  simple penetrating, of chest-wall, 378
  of spine, gunshot, 694
    symptoms of, 995
    treatment of, 695
    stab-, 694
      symptoms of, 695
      treatment of, 695
  of trachea, 157
    gunshot-wounds, 157
Wounds of trachea, gunshot-wounds, prognosis of, 158
    symptoms of, 158
  incised and stab-wounds, 158
    diagnosis of, 159
    prognosis of, 159
    symptoms of, 159
    treatment of, 160
Wry neck, 26
  anatomy of, 29
  congenital, 26
  diagnosis of, 32
  etiology of, 27
  muscular, 26
  prognosis of, 32
  symptoms of, 31
  treatment of, 32
  types of, 37
    dermatogenic contractures, 37
    myogenic contractures, 37
    neurogenic contraction, 37
    typical, 38